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AN EVALUATION OF THE NATIONAL EUTROPHICATION SURVEY DATA

WORKING PAPER NO. 900

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Because of the nation-wide scope of the National Eutrophication Survey and the time frame of less than four years for the completion of the sampling of 812 lakes and reservoirs, 4,000+ tributary sites, and over 800 municipal wastewater treatment plants, the Survey sampling program necessarily deviated from what ordinarily would be considered an ideal experimental design. As the Survey progressed, and to the degree permitted by the day-to-day work load, limited comparisons of Survey results with results published by others on the same water bodies were made. Specifically, it is concluded that: 1) the Survey water-body data compare very well with the reported data reviewed, considering the expected variability; 2) the trophic condition of most lakes and reservoirs can be adequately assessed on the basis of three periods of open-water sampling; 3) whether nitrogen, phosphorus, or some other element is limiting primary productivity in a water body can be inferred from algal assay results and nitrogen to phosphorus ratios; 4) considering temporal and spatial variability in nutrient concentrations, the Survey tributary nutrient data compare very well with the data reported by others; 5) for the purposes of the Survey, tributary nutrient loads were determined with acceptable accuracy with a sampling frequency of 14 times per year and flow data provided by the U.S.G.S.; 6) the Survey tributary total phosphorus loads and the in-water-body total phosphorus concentrations are highly correlated; 7) the effluent total phosphorus loads measured at 801 municipal wastewater treatment plants are in good agreement with expected values.

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An Evaluation of the
NATIONAL EUTROPHICATION SURVEY DATA

Working Paper No. 900

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National Eutrophication Survey
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I. CONCLUSIONS

Because of the nation-wide scope of the National Eutrophication Survey and the time frame of less than four years for the completion of the sampling of 812 lakes and reservoirs, 4,000+ tributary sites, and over 800 municipal wastewater treatment plants, the Survey sampling program necessarily deviated from what ordinarily would be considered an ideal experimental design. As the Survey progressed, and to the degree permitted by the day-to-day work load, limited comparisons of Survey results with results published by others on the same water bodies were made. More recently, in response to the concerns of the Ecology Advisory Committee of the Environmental Protection Agency's Science Advisory Board as to the credibility of the Survey data, a concerted effort has been made to test the validity of the data.

As a result of this effort, it is concluded that the reliability of the Survey data is better than would have been expected and that data sound enough to fulfill certain of the legislative mandates of Public Law 92-500 can be obtained with much less intensive and costly studies than previously thought necessary.

Specifically, it is concluded that:

1. The Survey water-body data compare very well with the reported data reviewed, considering the expected variability in such data.

2. The trophic condition of most lakes and reservoirs can be adequately assessed on the basis of three periods of open-water sampling.

3. Whether nitrogen, phosphorus, or some other element is limiting primary productivity in a water body can be inferred from algal assay results and nitrogen to phosphorus ratios.

4. Considering temporal and spatial variability in nutrient concentrations, the Survey tributary nutrient data compare very well with the data reported by others.

5. For the purposes of the Survey, tributary nutrient loads were determined with acceptable accuracy with a sampling frequency of 14 times per year and flow data provided by the U.S. Geological Survey.

6. The Survey tributary total phosphorus loads and the in-water-body total phosphorus concentrations are highly correlated.

7. The effluent total phosphorus loads measured at 801 municipal wastewater treatment plants are in good agreement with expected values.

II. INTRODUCTION

Largely as a result of the considerable controversy over the removal of phosphates in detergents, late in 1971, William D. Ruckleshaus, then the Administrator, committed the Environmental Protection Agency (EPA) to a nationwide assessment of the impact of phosphorus in municipal waste treatment plant discharges on freshwater lakes and reservoirs. For this purpose, the Office of Research and Development initiated the National Eutrophication Survey (NES) in early 1972 with the objectives of (1) identifying those lakes and reservoirs in the contiguous United States that receive nutrients from the discharges of municipal waste treatment facilities, (2) determining the effect of those point-source nutrient inputs on the nutrient levels and primary productivity of the water bodies, and (3) on the basis of that information, advising the Construction Grants Program of the then Office of Air and Water Programs on the cost-effective allocation of Federal funds for the construction of tertiary waste treatment facilities for phosphorus removal. Following the passage of amendments to the Federal Water Pollution Control Act in October, 1972 (Public Law 92-500), the NES objectives were broadened to include an assessment of the relationships of non-point sources (e.g., land use) to lake nutrient levels and also to assist in establishing water-quality criteria for nutrients.

In August, 1975, members of the Ecology Advisory Committee of EPA's Science Advisory Board visited the Corvallis Environmental Research Laboratory (CERL) to evaluate the ecological research programs of the Laboratory, including the National Eutrophication Survey - although as the name indicates, the NES was not conceived or conducted as a research program.

After a review of the Survey by several members of the Committee, an advisory statement was submitted to the Office of Research and Development, EPA, Washington, DC. The full text of the statement is appended; the specific recommendations were:

"In order to strengthen the credibility of the study, the Committee recommends that:

- The National Lake Survey data should be compared with existing data on the many well-studied lakes of similar type.
- The comparisons of the results should be discussed in personal conference with limnologists who have collected and assessed data on the same or similar lakes and impoundments covered by the National Lake Survey.
- The National Lake Survey estimation techniques should be applied to data already available on additional well-studied lakes and impoundments and those results should be compared. This will enable one to test the degree of error one may expect to find and thus provide an evaluation of the reliability of the Survey itself.

- Only after such comparison should further efforts at extrapolation and generalization through the computer be carried out."

Subsequently, a report on the Committee's assessment of the ecological research programs, dated July 26, 1976, was submitted to EPA. The portion of the report relating to the NES follows:

"4. AQUATIC STUDIES

a. Lake Eutrophication Survey

The Lake Eutrophication Survey involved characterization of 800 lakes and reservoirs by means of a helicopter and taking very few samples at each lake or reservoir. Some parts of the Survey (National Lake Survey) were very poorly designed, and it is questionable that the Survey will yield reliable results. A program designed to yield the maximum amount of information about a series of lakes from a few samples should have begun by a detailed analysis of lakes already intensively studied. By pretending to sample these lakes at infrequent intervals it would have been possible to determine (a) the best times to take samples, and (b) the extent of information loss resulting from the low level of sampling effort. From this information the potential value of the Survey could have been estimated and decisions made about the kinds of data most worth gathering. Failure to do this means that the characterization of the lakes is subject to biases that are unknown and cannot be reliably estimated. There is no way to judge the quality of the samples or their analyses, but the Committee can say positively that the lakes selected for sampling are not representative. One way to make this program more credible would be for individuals studying these various lakes to consult with scientists who have previous data on the same lakes to correlate their findings. The Committee was concerned that there would be a considerable effort to generalize from this Survey and that its admonitions to consult with limnologists to compare old and new data on the same lake would not be taken very seriously unless the Committee's objections were recognized at the Laboratory Director level or above. The Committee agreed that EPA should be very cautious about publication of results of this study. As an outcome of the Committee's concern, ECOLOGY ADVISORY STATEMENT -- THE NATIONAL LAKE SURVEY, October 23, 1975, (APPENDIX F) was forwarded to the attention of the Assistant Administrator for Research and Development.

> Members of the Committee discussed the possibility of EPA's initiating a periodic study on lakes in the context of their watersheds or drainage areas. Several lake-watershed areas could be selected in various parts of the country with different geologic substrates and developed into experimental basins. Testing of hypotheses by experimentation is clearly the best and most efficient way to develop sound management plans. As it stands, EPA's approach appears to be entirely piecemeal, or to try something and see what happens, instead of designing studies to test previously developed hypotheses."

It is the purpose of this report to respond to the recommendations of the Committee. This has proven to be a somewhat difficult and at times frustrating undertaking primarily because the number of usable lake data pairs is quite limited, and the suggested comparison of data on water bodies of "similar type" would not be expected to yield meaningful results; e.g., the chain of Wisconsin lakes known as the Madison Lakes are well-studied and are of similar type as to origin, latitude-longitude, and drainage basin; but each is distinctive, and the quality or characteristics of one cannot readily be inferred from the data available on one or more of the others. Also, budgetary constraints have not permitted the recommended "...personal conference with limnologists who have collected and assessed data on the same or similar lakes and impoundments..."; however, we have had correspondence and telephone conversations with a number of such individuals, particularly in the preliminary-report phase of the NES.

While comparable lake data are sparse, even fewer comparable data are available on measured tributary nutrient loads and point-source/non-point-source contributions to those loads. In only one of the reports reviewed was the method of calculation of loads given, and in others the nutrient loads reported are estimates based on factors such as land use (categorized or generalized), animal densities, population densities (usually the latest Census at the time the report was written), etc., but often different assumptions were used as to the relative nutrient flux attributable to each of the factors since "...considerable variation exists in the quantities of nutrients that are exported from 'similar' areas devoted to the same use" (Uttormark et al., 1974; pg. 100).

III. METHODS AND OPERATION OF THE SURVEY

Freshwater lakes and impoundments in the Survey were selected through consultation with EPA Regional Offices and state pollution control agencies, as well as related state agencies managing fisheries, water resources, or public health. EPA established selection criteria to limit the type and number of candidate water bodies, consistent with existing Agency water goals and strategies. For 27 states of the eastern United States where lakes were selected prior to passage of PL 92-500, strongest emphasis was placed on lakes faced with actual or potential accelerated eutrophication problems; e.g., an increased rate of algal and/or aquatic plant production. As a result, most of the selected lakes:

1. were impacted by one or more municipal sewage treatment plants, either directly or by discharge to an inlet tributary within approximately 40 kilometers of the lake;
2. were 40.5 hectares or larger in area; and
3. had mean hydraulic retention times of at least 30 days.

However, these criteria were waived for a number of lakes of particular interest to the states.

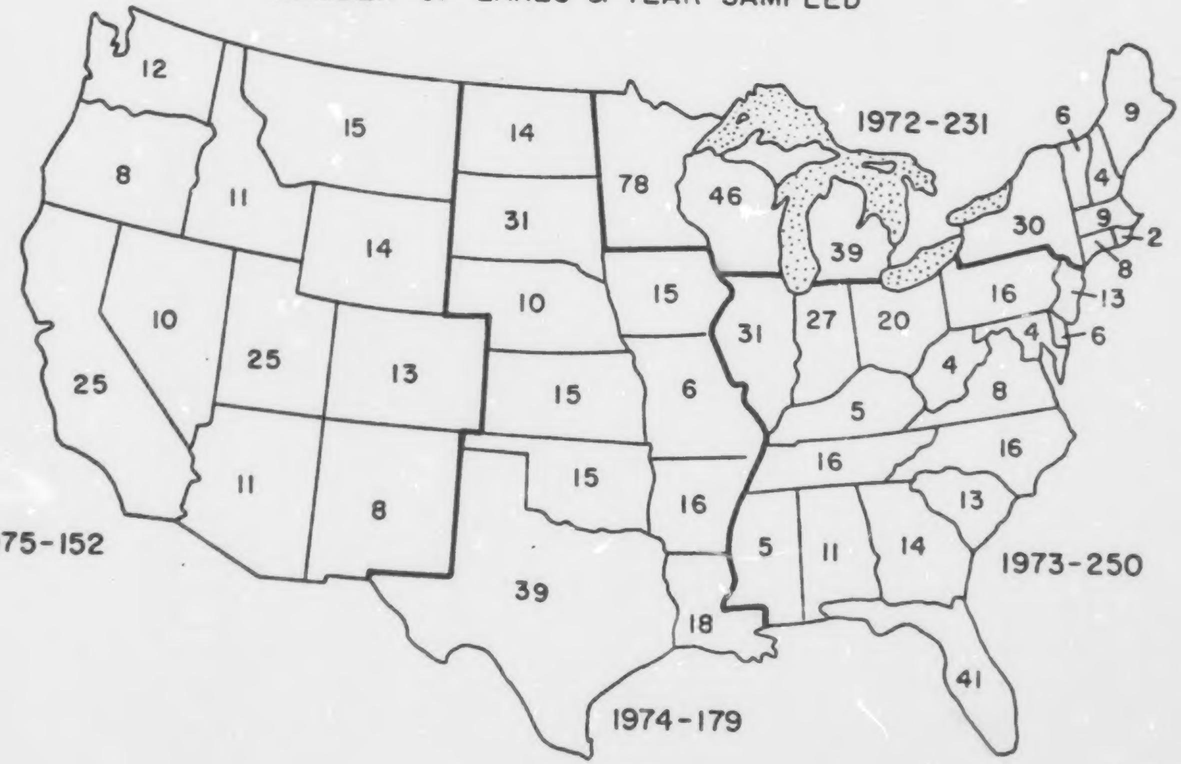
In the western states, these criteria were modified to reflect revised water-research mandates, as well as to address more prevelant non-point source problems in agricultural or undeveloped areas. Thus each state was requested to submit a list of candidate lakes for the Survey that:

1. were representative of the full range of water quality (from oligotrophic to eutrophic);
2. were in the recreational, water supply, and/or fish and wildlife propagation use-categories; and
3. were representative of the full scope of nutrient pollution problems or sources (from municipal wastes and/or nutrient-rich industrial discharges, as well as from non-point sources).

The size and retention time constraints applied in the eastern states were retained as was the waiver provision.

In all cases, listings of potential candidate lakes or reservoirs, prepared with the cooperation of the EPA Regional Offices, were made available to the states to initiate the selection process.

In total, the Survey included 812 lakes and reservoirs across the contiguous 48 United States. The map on the following page shows the distribution of the lakes and reservoirs by state and the year during which the water bodies were sampled.



NATIONAL EUTROPHICATION SURVEY
NUMBER OF LAKES & YEAR SAMPLED

GRAND TOTAL- 812

Several kinds of information are required for management decisions regarding the need for point or non-point source control of phosphorus and perhaps other nutrients as well. The Survey purpose was to collect the type of data which would provide a basis for such decisions or at least to provide a data base which could be supplemented with more detail, if required. First, an annual nutrient budget was estimated for each water body, differentiating between inputs from point and non-point sources; second, the existing trophic condition of the water body was evaluated by sampling; and third, an algal assay was performed to determine whether phosphorus, nitrogen, or some other element was limiting primary productivity of the water body. The methods used to gather this information are described below.

The operations aspects of the Survey were shared by branches of two EPA laboratories and a small Washington, DC headquarters staff. The Environmental Monitoring and Support Laboratory at Las Vegas, Nevada (EMSL-Las Vegas) was responsible for sampling each lake, doing the associated analyses, evaluating a portion of the data, and reporting results. The Corvallis Environmental Research Laboratory (CERL) at Corvallis, Oregon was responsible for coordinating the sampling of streams and sewage treatment plants, analyzing the samples, and performing the algal assay on lake samples. CERL also had the major responsibility for evaluating the lake, stream, and point-source data and incorporating these data into a report on each lake.

The headquarters staff made the initial contact with each state water pollution control agency to explain the function of the Survey and to cooperatively determine which lakes and reservoirs would be included. They also contacted each State National Guard to explain the function of the Survey and to request their assistance in meeting Survey objectives by collecting monthly samples from selected tributaries to surveyed lakes. In addition, the headquarters staff provided general coordination and guidance to the operational aspects of the program.

Because the Survey had to cover a large geographical area in a relatively short period of time, pontoon-equipped UH-1H Bell helicopters with automated and manually-operated instruments were used to measure the water quality of each lake. Two helicopters - carrying a limnologist and a technician - were operated simultaneously, and a third helicopter was used for ferrying parts, equipment, and people. The sampling teams from the EMSL-Las Vegas were supported by a mobile analytical laboratory, chemistry technicians, electronics specialists, and other staff involved with helicopter maintenance or program coordination.

Operating procedures involved establishing a work center at an airport and then sampling all lakes within a 100-mile radius. When all of the water bodies within the area were sampled, the support staff moved to a new central location, and sampling began on a different set of lakes. In this manner, from 150 to 250 lakes were sampled three or more times each year, and the sampling was completed on the 812 lakes in a four-year period.

Listed in the following table are the routine water-quality parameters which were selected to characterize each lake and assess the trophic condition. Parameter selection was based on the relevance of each parameter as a measure of potential and existing primary production. Both the number and the kinds of parameters measured also were limited to a certain extent by the operational aspects of the Survey.

WATER QUALITY CHARACTERISTICS MEASURED

Physical-Chemical

- Alkalinity
- Conductivity
- pH
- Dissolved oxygen
- Phosphorus:
  - Ortho
  - Total
- Nitrogen:
  - Ammonia
  - Kjeldahl
  - Nitrate-nitrite
- Secchi depth
- Temperature

Biological

- Algal assay
- Algal count and identification
- Chlorophyll *a*

Concurrently with the lake sampling, the significant tributaries and outlet(s) of each lake were sampled monthly, totaling about 4,200 sampling sites nationwide. Volunteer National Guardsmen of each state, trained on-site by EPA or state agency staff, collected and preserved the samples at sites pre-selected by EPA personnel. The samples were shipped to CERL for analysis of the various forms of nitrogen and phosphorus noted in the above table.

Through an interagency agreement, the U.S. Geological Survey estimated flows for each sampled stream. These data were used in conjunction with concentration values to determine nutrient loadings.

A voluntary sampling program was established through the respective state water pollution control agencies to have plant operators collect effluent samples from 1,000 or so municipal sewage treatment plants which impacted Survey lakes. The effluent samples were collected monthly, preserved, and shipped to the Corvallis laboratory for nitrogen and phosphorus analyses.

Specific procedures used in collecting, preserving, shipping, and analyzing the various kinds of samples collected by the Survey are described in National Eutrophication Survey Working Papers (U.S.EPA, 1974-1; 1975-175).

Presently, the sampling phase of the Survey has been completed, tributary sampling ended in November, 1975, the last treatment plant effluent samples were received in January, 1976, and laboratory analyses were finished in February, 1976. The individual lake reports are scheduled for completion by October, 1977.

IV. DATA COMPARISONS

In our effort to relate the Survey findings to information acquired by others, it soon became apparent that a lack of uniformity in data collection and reporting imposes a constraint on comparisons with other data that are available on the water bodies, streams, and point sources sampled by the NES. To be truly comparable, samples should be collected at the same time and place, analyzed by the same methods, etc., unless one is to ignore the expected within-lake, within-stream, within-year, and between-year differences in water quality. Furthermore, even with the most uniform procedures, "... two samples are always different, for the chance of two samples, even though drawn from exactly the same population, being identical in character is practically nil" (Simpson et al., 1960; pg. 172). Indeed, the need for statistical comparisons of data rests on this assumption.

A. In-Lake (Reservoir) Data -

Before comparing the NES lake and reservoir data, we deemed it instructive to examine the variability in lake sampling data. For this purpose, we analyzed data collected and reported in varying ways on seven lakes, most of which differ in geographic, geologic, and morphometric characteristics. The lakes are Geneva, Wisconsin; Minnetonka, Minnesota; four Finger Lakes, New York; and West Okoboji, Iowa. The morphology of these lakes is shown in the following table.

Lake	Area (km^2)	Mean Depth (m)	Maximum Depth (m)	Est. Mean Retention Time (yrs)
Geneva	21.30	18.6	41.1	24
Minnetonka	58.56	6.9	27.8	15
Conesus	12.89	9 (est)	18.9	24
Hemlock	8.37*	14 (est)	-	63
Owasco	27.45	29.3	53.9	26
Skaneateles	35.22*	43.5	-	121
W. Okoboji	15.40	11.9	40.8	20

Some examples of seasonal, between-year, within-year, within-lake, and between-lake differences in data are given in the next five tables where n = number of samples, r = range of values, $\bar{x}$ = the mean, $\bar{\bar{x}}$ = the mean of means, s = standard deviation, and V = Pearson's coefficient of variation in percent (Simpson et al., 1960).

Seasonal differences are shown in the following analyses of data resulting from 8 1/2 years of quarterly near-surface sampling at the same site on Lake Geneva by the Wisconsin Department of Natural Resources (Mason, 1976). The period of record is July, 1968, through November, 1976.

---

* Greeson and Robison, 1970

Lake Geneva, Wisconsin

Sampling Period	n	r	$\bar{x}$	s	V(%)
Soluble Reactive Phosphorus (μg/l)					
Winter	5	0-23	9.4	8.7	93
Spring	7	0-19	10.9	7.3	67
Summer	9	5-17	11.7	5.0	43
Fall	8	7-43	17.1	12.0	70
All data	29	0-43	12.6	8.6	68
Total Phosphorus (μg/l)					
Winter	6	10-40	25.0	10.5	42
Spring	7	10-40	25.7	9.8	38
Summer	8	20-40	25.0	7.6	30
Fall	8	20-70	40.0	17.7	44
All data	29	10-70	29.3	13.3	45
Inorganic Nitrogen (μg/l)					
Winter	6	40-410	203.3	151.2	74
Spring	8	100-420	165.0	127.4	77
Summer	5	40-320	162.0	106.4	66
Fall	7	100-190	148.6	36.3	24
All data	26	40-420	168.8	108.0	64
Total Nitrogen (μg/l)					
Winter	7	440-1,070	625.7	225.7	36
Spring	8	420-930	661.2	170.6	26
Summer	9	360-1,100	653.3	251.9	39
Fall	8	430-820	630.0	156.7	25
All data	32	360-1,100	643.4	233.2	36
Total Alkalinity (mg/l)					
Winter	7	157-192	179.4	13.1	7
Spring	8	179-188	183.1	2.9	2
Summer	9	162-185	173.0	6.4	4
Fall	7	172-186	179.3	5.7	3
All data	31	157-192	178.5	8.3	5
Secchi Disc Transparency (m)					
Winter	8	3.2-6.1	4.25	1.13	27
Spring	8	2.7-4.3	3.41	0.59	17
Summer	9	2.4-5.5	3.34	0.95	28
Fall	9	3.0-4.6	3.82	0.52	14
All data	34	2.4-6.1	3.70	0.87	24

Between-year differences are evident in the following analyses of data resulting from nearly three years of near-surface sampling at three- to four-week intervals at the same station on Lake West Okoboji, Iowa (Bachmann and Jones, 1974). The period of record is from 03/10/71 through 09/15/73.

Lake West Okoboji, Iowa; Station 49

Sampling Period	n	r	$\bar{x}$	s	V(%)
Soluble Reactive Phosphorus (μg/l)					
1971	14	0-30	16.4	12.2	74
1972	13	10-40	23.1	11.8	52
1973	18	0-30	14.4	7.8	54
All data	45	0-40	17.6	10.9	62
Total Phosphorus (μg/l)					
1971	3	20-70	50.0	26.5	53
1972	13	20-60	43.8	15.6	36
1973	18	10-40	27.2	7.5	28
All data	34	10-70	35.6	15.6	44
Inorganic Nitrogen (μg/l)					
1971	12	0-640	223.3	219.5	98
1972	13	110-330	201.5	65.3	32
1973	18	20-390	138.9	97.1	70
All data	43	0-640	181.4	138.0	76
Conductivity (μmhos)					
1971	14	326-466	437.6	42.9	10
1972	13	391-454	424.2	17.6	4
1973	18	375-476	437.6	29.8	7
All data	45	326-476	443.7	31.8	7
Secchi Disc Transparency (m)					
1971	10	2.3-4.5	2.95	0.69	23
1972	13	2.6-10.3	5.01	2.44	49
1973	18	2.8-11.7	5.72	2.79	49
All data	41	2.3-11.7	4.82	2.54	53

Within-lake, within-year, and between year differences are shown in the following table. The data resulted from about two years of near-surface sampling at two sites on Lake West Okoboji (Bachmann and Jones, 1974). The samples were collected at comparable times (within three days; usually less) during the period of 03/10/71 through 10/13/72.

Lake West Okoboji, Iowa; Stations 49 and 50

Period and Station	n	r	$\overline{x}$	s	V(%)
Soluble Reactive Phosphorus (μg/1)					
1971-49	13	0-30	15.4	14.8	96
-50	13	0-30	13.8	9.6	70
1972-49	10	10-40	20.0	11.5	58
-50	10	0-40	16.0	12.6	79
All data-49	23	0-40	27.8	21.0	76
-50	23	0-40	14.8	10.8	73
Total Phosphorus (μg/1)					
1971-49	2	20-70	-	-	-
-50	2	30-30	-	-	-
1972-49	10	20-60	44.0	16.5	38
-50	10	20-70	36.0	17.1	48
All data-49	12	20-70	44.2	18.3	41
-50	12	20-70	35.0	15.7	45
Inorganic Nitrogen (μg/1)					
1971-49	11	0-640	216.4	228.8	106
-50	11	0-550	182.7	214.5	117
1972-49	10	110-260	177.0	49.0	28
-50	10	30-360	167.0	103.9	62
All data-49	21	0-640	197.6	166.3	84
-50	21	0-550	175.2	167.1	95
Conductivity (μmhos)					
1971-49	13	326-466	438.9	35.4	8
-50	13	427-476	445.9	15.1	3
1972-49	10	406-454	427.8	15.7	4
-50	10	410-471	428.1	17.6	4
All data-49	23	326-466	434.1	28.6	7
-50	23	410-476	438.2	18.2	4

(Continued)

West Lake Okoboji, Iowa; Stations 49 and 50

Period and Station	n	r	$\bar{x}$	s	V(%)
		Secchi Disc Transparency (m)			
1971-49	9	2.3-4.5	2.87	0.67	23
-50	9	1.6-4.0	2.41	0.71	29
1972-49	10	2.6-7.3	4.40	1.70	39
-50	10	2.3-6.0	3.87	1.32	34
All data-49	19	2.3-7.3	3.67	1.50	41
-50	19	1.6-6.0	3.18	1.29	41

Another example of within-lake and within-year differences is given in the next table which is based on the data resulting from near-surface sampling on the same days at three sites on lower Lake Minnetonka (Megard, 1970). The sites were Megard's Gale Island (GI), Browns Bay (BB), and Wayzata Bay (WB) sampling stations, and the sampling period was from April through October 1969.

Lake Minnetonka, Minnesota

Station	n	r	$\bar{x}$	s	V(%)
		Soluble Reactive Phosphorus (μg/l)			
GI	6	7-10	8.2	1.2	15
BB	6	6-45	16.3	15.8	97
WB	6	3-8	6.3	2.0	32
		Total Phosphorus (μg/l)			
GI	7	36-66	49.9	11.9	24
BB	7	39-80	54.9	17.4	32
WB	7	35-72	47.6	13.5	28
		Inorganic Nitrogen (μg/l)			
GI	7	86-651	294.6	200.2	68
BB	6	178-857	390.7	245.9	63
WB	7	85-1,147	341.3	367.4	108
		Chlorophyll (μg/l)			
GI	6	14-40	24.7	9.4	38
BB	7	8-43	20.9	12.6	60
WB	7	8-38	20.6	11.9	58

Finally, between-lake differences are evident in the data on four of the Finger Lakes of New York reported by Oglesby (1972). The Finger Lakes are of similar type (type 30b; Hutchinson, 1957, pg. 86) and, chemically, "... the two westernmost lakes, Conesus and Hemlock, are similar to one another as are the three more eastern ones, Cayuga, Owasco and Skaneateles..." (Oglesby, op. cit., pg. 5). The analyses shown are based on the means of epilimnetic values for all sampling stations at each of the lakes from 07/06/71 through 11/03/71; i.e., the analyses are on populations of means. Had the raw values been used, the variation almost certainly would have been greater than shown (e.g., using the Lake Geneva seasonal means of soluble reactive phosphorus instead of the raw values would have resulted in V = 28 for "all data" rather than V = 68 as shown above).

Finger Lakes, New York

Lake	n	r	$\bar{\bar{x}}$	s	V(%)
Soluble Reactive Phosphorus (μg/l)					
Conesus	8	2.8-40.8	21.4	12.8	60
Hemlock	9	0.6-49.3	12.3	15.6	127
Owasco	10	4.1-27.0	12.2	7.8	64
Skaneateles	6	0.4-16.7	7.7	6.1	79
Nitrate-N (μg/l)					
Conesus	9	2-28	11.8	9.4	80
Hemlock	9	0-97	25.2	34.8	138
Owasco	9	71-281	171.8	64.7	38
Skaneateles	6	86-230	125.2	55.1	44
Chlorophyll a (μg/l)					
Conesus	8	2.08-21.78	6.75	6.55	97
Hemlock	7	2.6-18.3	6.6	5.3	80
Owasco	10	2.26-9.53	5.10	2.72	53
Skaneateles	4	1.38-3.55	2.34	1.04	44

The clear message of the above analyses is that variability in lake data is to be expected, particularly in nitrogen and phosphorus data. Note that the more-conservative parameters, alkalinity and conductivity, show much less variation.

To minimize the expected variation and permit valid comparisons, only data obtained by others on the same water bodies sampled by the NES and, to the degree possible, at the same or similar sampling sites, depths, dates, and years have been used to test the validity of the NES data.

First, prior to the Ecology Advisory Committee visit to CERL, Mason (1976) made a comparison of the NES data and Wisconsin Department of Natural Resources data on "six well-known and well-sampled Wisconsin lakes" (Mason, op. cit.) ranging in quality from oligotrophic Crystal Lake to hypereutrophic Lake Delevan. Although Mason's comparison included data from other depths, for brevity only the mean near-surface values are shown below; the numbers of samples are in parentheses.

Agency-Year	Secchi Disc (m)	Total Alkalinity (mg/l)	Conductivity (μmhos)	$NO_2 + NO_3 - N$ (μg/l)	$NH_3 - N$ (μg/l)	Total Phosphorus (μg/l)
			Big Green*			
DNR-1966	5.5 (7)	-	-	200 (10)	50 (10)	40 (17)
-1971-73	7.3 (19)	176 (18)	421 (16)	90 (18)	<30 (18)	50 (10)
NES-1972	6.4 (3)	170 (3)	377 (3)	80 (3)	30 (3)	30 (3)
			Crystal*			
DNR-1966	7.9 (8)	-	-	70 (11)	50 (11)	30 (11)
-1971-73	7.9 (6)	4 (6)	17 (6)	30 (6)	100 (6)	20 (6)
NES-1972	7.9 (3)	<10 (3)	<50 (3)	30 (3)	40 (3)	6 (3)
			Delevan*			
DNR-1966	1.5 (9)	-	-	240 (11)	230 (11)	170 (11)
-1971-73	3.4 (11)	177 (19)	484 (16)	200 (17)	250 (19)	140 (19)
NES-1972	1.5 (3)	163 (3)	438 (3)	110 (3)	310 (3)	120 (3)
			Geneva*			
DNR-1966	4.6 (9)	-	-	200 (10)	50 (10)	40 (10)
-1971-73	3.7 (19)	178 (18)	396 (17)	60 (17)	60 (19)	40 (19)
NES-1972	3.4 (3)	176 (3)	375 (3)	40 (3)	30 (3)	13 (3)
			Trout*			
DNR-1966	4.0 (7)	-	-	90 (10)	40 (10)	50 (10)
-1971-73	4.6 (10)	42 (10)	100 (8)	80 (10)	<30 (10)	20 (10)
NES-1972	4.6 (3)	39 (3)	94 (3)	30 (3)	40 (3)	10 (3)
			Winnebago*			
DNR-1966	0.7 (7)	-	-	270 (10)	90 (10)	130 (10)
-1971-73	1.2 (17)	146 (17)	335 (14)	290 (18)	140 (18)	150 (18)
NES-1972	0.7 (3)	138 (3)	301 (3)	130 (3)	110 (3)	100 (3)

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*Respectively, Working Papers No. 39, 66, 36, 61, 71, and 57

In his independent assessment, Mason concluded that "the most significant point is that when you consider the surveys were carried out independently and by different methods - different people, different sampling techniques, and, most importantly, different laboratories - the data... compare remarkably well. There are some minor differences, of course, but...EPA should be able to classify the lakes they have sampled fairly accurately even with their limited amount of data".

Another comparison of NES data and the Wisconsin Department of Natural Resources (DNR) data provided by Mason is tabulated below. The results are from sampling Big Green Lake in 1972 at the same site and on dates and at depths as comparable as is possible.

Agency-Date	Depth (m)	Total P (µg/l)	Inorganic N (µg/l)	pH (units)	Total Alk. (mg/l)	Conductivity (µmhos)	Secchi Disc (m)
DNR-04/27	near-surface	30	123	8.2	176	329	7.3
NES-06/22	near-surface	29	70	8.8	173	345	5.6
DNR	21.3	40	133	8.2	177	358	-
NES	18.9	50	230	8.2	179	350	-
DNR-07/18	near-surface	40	<90	8.8	177	400	5.8
NES-08/21	near-surface	11	70	8.5	169	370	6.1
DNR	21.3	50	210	8.0	179	300	-
NES	24.4	53	330	7.9	178	290	-
DNR	44.2	70	250	8.0	179	275	-
NES	45.7	78	400	7.8	176	390	-
DNR	67.0	260	677	7.8	180	280	-
NES	62.5	249	580	7.5	182	395	-
DNR-11/21	near-surface	30	280	8.3	174	365	7.6
NES-11/08	near-surface	28	210	8.3	169	415	7.6
DNR	21.3	40	300	8.2	180	370	-
NES	22.9	34	250	8.2	180	410	-
DNR	44.2	70	350	8.1	182	360	-
NES	45.7	83	350	7.7	183	410	-
DNR	67.0	190	370	8.2	192	379	-
NES	60.3	109	410	7.6	184	410	-

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The results of the statistical analyses of these data are shown below where n, $\bar{x}$, s, and V are as previously defined, C is Spearman's coefficient of rank correlation, and t = Student's two-tailed t-test for the difference between paired samples (Simpson et al., 1960). Note, however, that pH values are logarithms of the reciprocal of the normality of free hydrogen ions (Welch, 1952); and, except for C, statistical analyses of the pH units per se are incorrect mathematically (Barth, 1975). Therefore, the pH units were converted to the respective hydrogen ion concentrations in moles/l, and the statistical analyses were made using those numbers. The means and the standard deviation were then converted back to pH units (note that -s does not equal +s because the values shown are logarithms; in terms of concentrations [moles/l], the NES $\bar{x}$ is 1.2751×10^{-8}, and s is $\pm 1.0166 \times 10^{-8}$; the DNR $\bar{x}$ is 7.5628×10^{-9}, and s is $\pm 3.7890 \times 10^{-9}$). Since the t and V values are ratios, they have not been converted to logarithms.

Agency	n	$\bar{x}$	s	V(%)	C	t
			Total Phosphorus			
DNR	10	82.0	78.4	96	0.92	1.090
NES	10	72.4	68.8	95		
			Inorganic Nitrogen			
DNR	10	278.3	133.7	48	0.81	0.386
NES	10	289.0	159.0	55		
			pH			
DNR	10	8.12	-0.18,+0.30	50	0.71	0.676
NES	10	7.89	-0.25,+0.70	80		
			Total Alkalinity			
DNR	10	179.6	4.9	3	0.91	1.746
NES	10	177.3	5.5	3		
			Conductivity			
DNR	10	341.6	43.3	13	0.32	3.046
NES	10	388.5	35.5	7		
			Secchi Disc			
DNR	3	6.90	0.96	14	0.50	1.204
NES	3	6.43	1.04	16		

Except for conductivity, the t-tests indicate none of the differences between means are significant at the 5% probability level, and the coefficients of rank correlation indicate the DNR and NES data compare quite well (the relatively low C value for Secchi disc probably results from differences in sampling times of as much as two months).

The null hypothesis of no difference between the conductivity means is rejected at the 5% probability level. The reason for the difference in the conductivity measurements is not known but could have been the result of differing temperature compensation/correction. It will be noted the NES values were higher than DNR's in eight of the ten pairs.

Below, 1972 NES total phosphorus data (in µg/1) are compared to unpublished EPA Shagawa Lake Project data from two sampling sites at similar but not identical depths on similar but not the same sampling days. NES stations 1 and 2 correspond to Project stations B and E, respectively, and the depths sampled range from near-surface to a maximum of 12.1 meters (usually to about 9 meters). The statistical symbols shown have been defined previously.

	Station & Date			Station & Date		
	B	#1	B	E	#2	E
	07/05	07/08	07/11	07/05	07/08	07/11
	24	33	24	30	34	32
	30	29	25	31	34	28
	59	38	49	42	192	39
	174	164	271	78	214	143
	287	381	425	587	390	737
$\bar{x}$=	114.8	129.0	158.8	153.6	172.8	195.8
s=	113.7	151.8	181.4	243.1	148.1	306.3
V=	99	118	114	158	86	156
	B	#1	B	E	#2	E
	09/05	09/07	09/12	09/05	09/07	09/12
	102	64	89	78	65	90
	97	66	90	81	61	96
	93	87	84	76	60	87
	83	87	87	89	69	80
	93	102	81	330	303	145
$\bar{x}$=	93.6	81.2	86.2	130.8	111.6	99.6
s=	7.0	16.0	3.7	111.5	107.1	26.0
V=	7	20	4	85	96	26
	B	#1	B	E	#2	E
	10/16	10/22	10/24	10/17	10/22	10/24
	68	35	47	50	40	52
	86	50	74	61	47	83
	53	40	49	56	48	55
	59	41	48	53	37	53
	55	38	51	53	37	51
$\bar{x}$=	64.2	40.8	53.8	54.6	41.8	58.8
s=	13.5	5.6	11.4	4.2	5.4	13.6
V=	21	14	21	8	13	23

The above comparisons show good agreement between the NES data and the Project data for both stations and sampling days in July and for both sampling days at Project station E in September. However, an inverse relationship is apparent in the September NES station 1 and Project station B data; and in October, NES values are lower than Project values at both stations and sampling days.

The distribution-free Kruskal-Wallis H test (Downie and Heath, 1970) was used to test whether the three sets of samples were from the same or different populations. The results indicate a significant difference at the 5% level at both Project stations in October but not at either station in July or September. Student's t-tests were then computed to determine the significance of differences in means, and the null hypotheses of no difference are rejected at the 5% level for the means of NES station 1 October data and Project station B October 16 data as well as the means of NES station 2 October data and Project station E October 17 and 24 data.

Coefficients of rank correlation show good agreement between NES and Project data in July, fairly good agreement between NES station 2 and Project station E data in September and October, and also the inverse relationship noted above between NES station 1 and Project station B data in September (negative C values). Overall, the coefficients indicate the correlation between NES data sets and Project data sets is about as good as the correlation between comparable Project data sets.

The results of the statistical analyses are tabulated on the next page.

Stations and Dates	H	C	t
B-7/5; #1-7/8; B-7/11	0.015	-	-
B-7/5; B-7/11	-	1.00	0.460
B-7/5; #1-7/8	-	0.90	0.167
B-7/11; #1-7/8	-	0.90	0.282
E-7/5; #2-7/8; E-7/11	0.560	-	-
E-7/5; E-7/11	-	0.90	0.241
E-7/5; #2-7/8	-	0.98	0.151
E-7/11; #2-7/8	-	0.98	0.151
B-9/5; #1-9/7; B-9/12	3.185	-	-
B-9/5; B-9/12	-	0.58	2.093
B-9/5; #1-9/7	-	-0.68	1.586
B-9/12; #1-9/7	-	-0.82	0.680
E-9/5; #2-9/7; E-9/12	4.160	-	-
E-9/5; E-9/12	-	0.40	0.609
E-9/5; #2-9/7	-	0.90	0.278
E-9/12; #2-9/7	-	0.30	0.244
B-10/16; #1-10/22; B-10/24	9.400	-	-
B-10/16; B-10/24	-	0.10	1.256
B-10/16; #1-10/22	-	0.30	3.582
B-10/24; #1-10/22	-	0.55	2.287
E-10/17; #2-10/22; E-10/24	9.380	-	-
E-10/17; E-10/24	-	0.82	0.660
E-10/17; #2-10/22	-	0.60	4.220
E-10/24; #2-10/22	-	0.72	2.599

While the cause(s) of the partial differences between NES and Project data cannot be identified with certainty, there are at least two possibilities: (1) sampling methods and (2) sample analyses.

Project samples were collected by means of Van Dorn samplers ranging in size from 4-liter capacity (45 by 10 cm) to 8-liter capacity (78 by 13 cm). Typically, the midpoint of the sampler was positioned as nearly at the desired depth as wind and wave would permit, and a vertical column of water of from nearly 1/2 meter to 3/4 meter in height (depending on the size of the sampler used) was removed as the sample. Survey sampling, on the other hand, was by means of a submersible pump with the intake positioned at the selected depth (again varying somewhat depending on wave conditions). While there is no way of knowing what distances radially from the pump intake water was drawn, the maximum rate of the pump used in 1972 was only about 7 liters per minute, and it seems likely that the Survey samples were from more-limited strata than the Project samples. Also, as noted previously, NES and Project samples were not from exactly the same depths; there were differences as great as 0.8 meters, and Project data show as much as 485 μg/l change in total phosphorus with an increase of 1.5-meters in depth (9 to 10.5 meters at station B on 09/05/72).

While sampling methods may have resulted in some differences, the consistently lower NES concentrations in October probably were due in some part to differences in analyses since Shagawa Lake was homothermous and relatively well-mixed at that time.

In early 1973, sets of analytical quality control replicate samples were prepared at CERL and were sent to EMSL-LV and the Project laboratory at Ely for analyses of nitrogen and phosphorus species. The results of this round-robin testing for total phosphorus are shown in the following table.

Total Phosphate Phosphorus
(mg/l)

Sample #	Corvallis	Ely	Las Vegas
1	0.145	0.194	0.169
2	0.15	0.176	0.156
3	0.16	0.183	0.163
4	0.15	0.187	0.153
5	0.16	0.19 (u)*	0.163
$\bar{x}$=	0.153	0.185	0.161
s=	0.007	0.008	0.006

* Unreliable; not used in calculations

It will be noted that the mean of the Ely values for this series is 15% higher than the mean of the Las Vegas (EMSL) values. From this it cannot be said the analyses of one laboratory are better than those of the other, since the true value of total phosphorus in the sample from which the aliquots were drawn (a composite of tributary samples) is not known. However, if similar differences occurred in the analyses of the October Shagawa Lake samples, that would account for a major portion of the apparent differences between NES and Project data.

In the interests of brevity and conservation of typing effort, generally in succeeding comparisons only the pertinent data will be given. Statistical analyses will be shown only where necessary for a better understanding of the significance of differences between NES data and data collected by others.

At Big Spirit Lake, Iowa, Bachmann and Jones (1974) collected only near-surface samples on September 15, 1973 at three stations corresponding to NES stations sampled on September 23, 1974:

Agency & Station	Sol. Reactive P (μg/l)	Total P (μg/l)	Dissolved Oxygen (mg/l)	Secchi disc (m)
B&J-54.4	10	40	9.5	1.2
NES-1	6	38	9.0	1.4
B&J-54.0	10	40	9.1	1.4
NES-2	13	58	9.2	1.1
B&J-54.1	0	30	9.3	1.4
NES-3	7	40	9.4	1.2

On the same date (09/15/73), they collected samples to 35 meters in depth at one station on Lake West Okoboji corresponding to a NES station sampled to 39 meters in depth on 09/23/74. In the following table, only data from comparable depths are shown.

Agency	Depth	Sol. Reactive P (μg/l)	Total P (μg/l)	Dissolved Oxygen (mg/l)	Secchi disc (m)
B&J	near-	10	30	7.2	2.8
NES	surface	24	46	8.0	2.6
B&J	mid-	10	33	6.9	-
NES	depth	26	54	7.9	-
B&J	near-	245	250	1.2	-
NES	bottom	146	270	2.6	-

Total phosphorus data obtained by Megard (1970) at eight stations on Lake Minnetonka in June, September, and October, 1969 were compared to NES data obtained at the same stations in June, September, and October, 1972. The means of all of the water column values at similar depths were calculated. The mean of Megard's data is 58.9 μg/l, and the mean of NES data is 53.1 μg/l. The null hypothesis of no difference between the means is accepted at the 60% probability level (t=0.507; degrees of freedom [d.f.]=44).

Nutrient data for a number of TVA reservoirs reported by Brye (1970) were obtained in various years ranging from 1963-64 (Guntersville Reservoir, AL) to 1968-69 (Nottely Reservoir, GA); the NES data were obtained in 1973. The data compared are the means of all water column values for corresponding TVA and NES sampling stations and depths, except for Douglas and Nottely reservoirs (means of epilimnetic values). Overall, the data are quite comparable, particularly when the differences in sampling times are considered.

Reservoir	Agency & Station	Total P (μg/1)	Total N (μg/1)
Douglas, TN	TVA-54.0	39	680
	NES-2	27	594
	TVA-43.0	25	700
	NES-3	22	625
	TVA-33.0	24	640
	NES-6	20	681
Nottely, GA	TVA-21.1	17	390
	NES-1	14	397
	TVA-27.5	16	340
	NES-3	17	341
Guntersville, AL	TVA-358.0	47	240
	NES-2	47	786
	TVA-369.7	49	220
	NES-4	43	844
	TVA-385.9	46	290
	NES-8	47	826
Wilson, AL	TVA-259.7	46	670
	NES-1	46	625
	TVA-265.0	67	902
	NES-2	42	624
	TVA-273.5	41	620
	NES-3	63	647
Pickwick, AL	TVA-207.6	77	710
	NES-1	57	734
	TVA-220.0	101	890
	NES-3	59	674
	TVA-245.0	78	840
	NES-6	57	750
Kentucky, KY, TN, & MS	TVA-23.0	70	870
	NES-1	78	738
	TVA-42.0	74	910
	NES-3	85	640
	TVA-66.0	90	920
	NES-6	76	780
	TVA-91.0	139	770
	NES-10	62	778
	TVA-112.0	79	530
	NES-17	56	682

Limited water quality data obtained at Lake Norman, NC, by the Duke Power Company (DPC) were provided by Bowling (1976). The Company data are from 08/27/73 and 09/24/73 sampling at three stations corresponding to three NES stations that were sampled on 07/17/73 and 09/19/73. The values shown are means of values at comparable sampling depths.

Agency & Station	Depth	Sol.Reactive P (µg/l)	Total P (µg/l)	Alkalinity (µg/l)
DPC-1 NES-1	near-surface	7	16	14
		8	13	20
	mid-depth	5	18	20
		4	8	19
	near-bottom	7	25	21
		3	12	22
DPC-11 NES-3	near-surface	5	12	19
		6	12	17
	mid-depth	5	14	19
		3	10	20
	near-bottom	5	56	18
		4	12	18
DPC-13 NES-4	near-surface	5	14	13
		5	15	17
	mid-depth	6	15	22
		6	15	18
	near-bottom	5	37	18
		5	21	18

The above data compare very well except for the DPC near-bottom total phosphorus values which were consistently higher than NES values.

Water quality data for Lake Wylie, NC, were reported by Gerhold (1975). His data obtained in April and July, 1974, are compared to NES data obtained at the same station (NES-4) in April and July, 1973.

Data Source	Sol. Reactive P (µg/l)	Total P (µg/l)	Total N (µg/l)	Alkalinity (mg/l)
G-04/74	3	42	483	9
NES-04/73	6	45	490	11
G-07/74	4	31	469	11
NES-07/73	3	20	480	18

Collings (1973) reported U.S. Geological Survey water quality data for a number of lakes in the State of Washington, including American Lake which was sampled by the NES in 1975. The U.S.G.S. data were obtained in 1969 and 1970 at "north end" and "south end" of the lake stations that are assumed to correspond to NES stations 3 and 1, respectively. The data compared are from as similar depths as possible in October, 1970, and October, 1975.

Data Source	Depth (m)	Sol.Reactive P (µg/l)	Total P (µg/l)	Total N (µg/l)	Alkalinity (mg/l)
C-North	0.9	6	13	180	41
NES-3	1.5	2	21	220	41
C-North	13.4	6	10	130	42
NES-3	15.2	76	100	620	45
C-North	26.5	160	200	1800	42
NES-3	23.5	167	306	2120	45
C-South	0.9	6	6	300	41
NES-1	1.5	31	70	320	43
C-South	13.4	6	10	180	43
NES-1	7.3	27	86	520	42

Except for alkalinity and the nutrient values for the deepest samples at NES station 3, the above data do not compare too well. The general lack of agreement is not surprising in view of the uncertainty as to the location of the U.S.G.S. sampling stations and the lapse of five years between the two sampling efforts.

Recently, Welch (1977) reported the effects of nutrient diversion on Lake Sammamish, Washington. Some of the 1975 water quality data resulting from that study were provided by Welch (personal communication) and are compared to 1975 NES data from the same sampling station at times and depths as similar as possible:

Source & Date	Depth (m)	Sol. Reactive P (µg/l)	Total P (µg/l)	Diss. Oxygen (mg/l)	Secchi Disc (m)
W-03/27	near-	2	16	12.8	2.5
NES-03/31	surface	-	25	13.2	2.6
W	1.0	2	16	12.9	
NES	1.5	-	21	13.0	
W	5.0	2	15	12.9	
NES	6.1	3	39	13.0	
W	10.0	2	16	12.8	
NES	12.2	3	29	12.6	
W	20.0	2	14	12.6	
NES	18.2	4	35	12.6	
W	25.0	2	-	12.6	
NES	24.4	4	90	12.4	

(Continued)

Source & Date	Depth (m)	Sol. Reactive P (µg/l)	Total P (µg/l)	Diss. Oxygen (mg/l)	Secchi Disc (m)
W-07/31	near-surface	5	12	11.6	3.0
NES-07/17		5	13	10.6	3.7
W	1.0	5	16	11.4	
NES	1.5	5	11	10.8	
W	5.0	8	14	11.5	
NES	4.6	11	13	10.6	
W	10.0	1	7	10.9	
NES	9.1	12	12	10.8	
W	15.0	2	14	7.0	
NES	15.2	12	12	8.2	
W	20.0	4	17	3.8	
NES	21.3	17	18	2.4	
W-11/11	near-surface	5	18	10.3	2.5
NES-10/28		5	17	9.0	3.7
W	1.0	4	18	10.6	
NES	1.5	4	15	9.2	
W	5.0	5	17	10.7	
NES	5.5	9	19	7.8	
W	15.0	4	22	10.6	
NES	16.8	7	22	-	
W	20.0	4	22	10.6	
NES	22.9	3	15	6.8	

Except for March total phosphorus and July soluble reactive phosphorus, the data compare very well. The NES March total P values are consistently greater than Welch's values, and the null hypothesis of no difference between the means is rejected at the 5% probability level (t = 4.382 with 8 d. f.). However, Lake Sammamish was homothermous and well-mixed at that time (note the uniform dissolved oxygen values), and changes in non-conservative parameters would not be unexpected. For example, the null hypothesis of no difference between the means of total P values obtained by Welch on March 11 and 27 at identical depths is also rejected at the 5% probability level (t = 4.999 with 16 d. f.).

The reason for the difference in July soluble reactive P is not known, but it will be noted that the differences occurred at the 10, 15, and 20 meter depths where NES data indicate all of the phosphorus was soluble (i.e., SP = TP). Also, at two greater depths not sampled by NES (25 and 27 meters), Welch's SP values increased to 12 µg/l, but his TP values increased proportionately as well.

Finally, limited data for Oregon's ultra-oligotrophic Waldo Lake (Malueg et al., 1972) and meso-eutrophic Diamond Lake are shown below. The NES 1975 data are compared to unpublished 1975 data obtained in a continuing program of monitoring the two lakes by the Marine and Freshwater Ecology Branch of CERL. Sampling times and depths are as similar as possible; however, at both lakes, the NES sampling station was at least 0.8 km removed from the comparable CERL station.

The Waldo Lake data were obtained on 09/04/75 by CERL and on 10/31/75 by NES:

Agency	Depth (m)	Sol. Reactive P (μg/l)	Total P (μg/l)	Total N (μg/l)
CERL	near-surface	<5	<10	< 80
NES		3	6	<220
CERL	20.0	<5	<10	55
NES	15.2	2	4	<220
CERL	40.0	<5	10	55
NES	41.1	2	5	<220
CERL	60.0	<5	<10	-
NES	53.3	<2	4	<220

About all that can be said about the above data is that they indicate the problem of analysis of very low levels of nutrients.

The Diamond Lake data were obtained by CERL on 07/10/75 and by NES on 07/16/75:

Agency	Depth (m)	Total P (μg/l)	Total N (μg/l)
CERL	near-surface	20	355
NES		11	220
CERL	5.0	28	305
NES	4.6	11	220
CERL	10.0	35	355
NES	9.1	45	320

The NES and CERL data on Diamond Lake do not compare too well, except for the 10-meter level. How much of the difference is real and how much is due to the distance between the two sampling stations is uncertain. However, the results of NES sampling at the same time at a second station somewhat further removed from the CERL station are very similar to the CERL values; i.e., total P ranging from 30 to 37 μg/l and total N of 400+ μg/l ($NO_2 + NO_3 =$ <20 μg/l).

B. Trophic Condition -

1. Assessment -

A part of the evaluation of the water bodies sampled by the NES included an assessment of trophic condition based on Survey data and the data of others and categorization in terms of the classical descriptors, oligo-, meso-, and eutrophic.

While there is general agreement in the scientific community as to the fundamental concepts of trophic condition, recently reviewed by Hutchinson (1973), there is some divergence in interpretation of the relative significance of parameters commonly used in a trophic assessment (e.g., nutrients, dissolved oxygen, chlorophyll, plankton kinds and numbers, transparency, benthic organisms, fish species and abundance, etc.), possibly because many of the physical, chemical, and biological relationships in aquatic ecosystems are not well-understood. Because of this, assessments provided by aquatic scientists are to a degree subjective, and the designations of trophic condition made by one worker may not be wholly acceptable to all others.

Among the parameters measured by the NES, trophic assessment primarily and consistently was based on the following generally accepted indicators of trophic condition:

Parameter	Condition		
	Oligotrophic	Mesotrophic	Eutrophic
Total Phosphorus (μg/l)	<10	10-20	>20-25
Chlorophyll a (μg/l)	< 4	4-10	> 10
Secchi depth (meters)	> 3.7	2.0-3.7	< 2.0
Hypolimnetic Dissolved Oxygen (% saturation)	>80	10-80	< 10

In addition to the above criteria, the phytoplankton were evaluated.

The rationale for the parameter limits in the above table is as follows:

Total phosphorus - the 10 μg/l limit was first suggested by Sawyer (1947) and was adopted by Vollenweider (1968) as an "oligotrophic" level with a "eutrophic" level of twice that. The Vollenweider limits have since been adopted by others; i.e., Dillon (1975) and Larsen and Mercier (1976).

Chlorophyll a - The limits are those recommended by the Environmental Studies Board of the National Academies of Science and Engineering (1972).

Secchi depth - the oligotrophic limit is based on the mean value for Wisconsin lakes in which there was no deterioration of recreational potential due to plankton growths (Lueschow et al., 1970). The eutrophic limit approximates that proposed as a minimum for primary contact recreation (1.2 m) by the National Technical Advisory Committee (1968).

Dissolved oxygen (DO) - the saturation limits may be somewhat arbitrary but are based on the generally accepted premises of an orthograde DO curve with little or no depression with depth in oligotrophic lakes, a clinograde DO curve in mesotrophic lakes with some depression with depth, and a clinograde DO curve in eutrophic lakes with marked depression or depletion with depth.

The evaluation of phytoplankton primarily involved numbers, kinds, and associations (Hutchinson, 1967), although some indices were utilized with caution; i.e., Nygaard's indices (Nygaard, 1949), Palmer's organic pollution indices (Palmer, 1969), and a species diversity and abundance index (Shannon and Weaver, 1963).

Other than the 500 organisms per milliliter proposed by Lackey (1945), which we judged to be too restrictive, we could not find a quantitative definition of a phytoplankton "bloom" in the literature, and the following criteria were more or less arbitrarily adopted (disregarding spring diatom pulses):

Oligotrophy - less than 1000/ml; filamentous blue-green algae essentially absent in all samples.

Mesotrophy - less than 5000/ml; filamentous blue-green algae, if present, not dominant in any sample.

Eutrophy - more than 5000/ml with filamentous blue-green algae common but not necessarily dominant; or, 1000 or more/ml with filamentous blue-green algae dominant in most or all samples.

In the application of the five physical, chemical, and biological limits discussed above, it was not unusual to find a lake meeting, say, one criterion for oligotrophy, three criteria for mesotrophy, and one criterion for eutrophy (such a lake would be categorized as mesotrophic), or meeting two criteria for oligotrophy and three for mesotrophy (categorized as oligo-mesotrophic), or meeting two criteria for mesotrophy and three for eutrophy (categorized as meso-eutrophic). However, those water bodies classified as oligotrophic met all five of the criteria for oligotrophy.

Also, in many large reservoirs, it was found that the major tributary embayments (nearest the nutrient sources) are eutrophic while the main body of the impoundment is mesotrophic (or even oligotrophic in the case of Garrison Reservoir, ND). Similarly, spatial differences in trophic condition were evident in a few large lakes such as Champlain, NY and VT; Winnipesaukee, NH; and, particularly, in Memphremagog, VT and Quebec, in which the south (U.S.) end is eutrophic and the north (Canada) end is oligotrophic.

Our assessment of oligo- and mesotrophic conditions on the basis of the key parameters seldom involved significant differences of opinion with others; however, most of the water bodies included in the NES are eutrophic because (1) initially selection primarily was based on municipal point-source impact and (2) later, when the selection criteria were changed, many of the water bodies were in areas of high natural fertility as in the corn belt and many of the western states. Not only because of the preponderance of eutrophic water bodies among those sampled by the NES, but also because the term "eutrophic" encompasses a broad continuum of trophic conditions ranging from relatively good to very poor, more disagreement resulted from our assessment of this condition. Indeed, in some geographic areas, most of the water bodies sampled are eutrophic, but there is local resistance to calling them that because of a supposed implication of poor management of those waters.

2. Trophic Index -

Early in the NES, it became apparent that a ranking system would be useful in assessing the trophic condition of the water bodies studied, as well as provide the users of NES reports a measure of the relative quality of a particular water body within the diverse group categorized as "eutrophic". Therefore, a percentile trophic index was devised (the development, utility, and shortcomings of the index are discussed in Working Paper No. 24 [U.S.EPA, 1974-24]).

While there appear to be drawbacks to any trophic ranking system, most likely because of an insufficiency of comparable data (Hooper, 1969), the concept appeals to those who feel the classical terminology is too inflexible, and indices have been proposed recently by Carlson (1977), Harkins (1974), and Uttormark and Wall (1975). Carlson proposes a single-parameter index, Harkins uses multivariate analysis, and the Uttormark and Wall index is largely based on subjective information obtained by questionnaires.

The NES index has been compared with the Carlson index and the Harkins index using data on 39 south-central water bodies. Spearman's coefficient of rank correlation (Simpson et al., 1960) was calculated between the NES and Harkins rankings, between the NES and Carlson rankings, and between the Harkins and Carlson rankings in two-by-two pairs. The coefficient of correlation between the NES and Harkins is 0.97, between the NES and Carlson is 0.86, and between Harkins and Carlson is 0.82.

These rather high correlation values suggest that there is a high degree of association among the three methods, that the rank order is very similar whichever index is used, and that the NES relative trophic index compares very well with the other two indices.

C. Limiting Nutrient -

"It is generally considered reasonable to start any investigation by assuming what is usually called Liebig's Law of the Minimum holds at least approximately" (Hutchinson, 1973, pg. 274). Phosphorus and nitrogen have long been recognized as limiting elements in aquatic ecosystems (Sawyer, 1947; Deevey, 1972).

In the NES assessment of limiting nutrient, only phosphorus and nitrogen were evaluated, although it was recognized a priori that other elements can be limiting (Goldman, 1972) as well as such physical variables as light, temperature, and mixing of the water mass. The determination was made by two methods - nutrient-spiked algal assays and the in-lake (reservoir) inorganic nitrogen/orthophosphorus weight ratios.

1. Algal Assays -

Depending on the size and/or complexity of the water body, one or more depth-integrated (through the photic zone) samples were collected during the last sampling visit (1972 and 1973) or the first and last sampling visits (1974 and 1975). The samples were shipped to CERL, and algal assays were performed to determine the limiting nutrient and the potential primary productivity of the water body at the time the sample was taken (U.S. EPA, 1971). The growth response of the test alga, Selenastrum capricornutum Prinz, to spikes of phosphorus or nitrogen indicated the limiting nutrient. In all cases, the assay results were evaluated with respect to the nutrient levels and ratios in the water body at the times and places the samples were collected; when there were substantial differences, the assay results were not considered representative of conditions in the water body at the time of sampling, and the in-water-body N/P ratios were used to determine the limiting nutrient.

In a few of the assay samples, there was no growth response to phosphorus and nitrogen, alone or in combination, indicating limitation by some other element or by some other factor such as toxicity. In other samples, growth response occurred only when phosphorus and nitrogen were added in combination, indicating co-limitation; in the latter cases, the control sample inorganic N/P ratios generally were about 13/1.

2. N/P Ratios -

Although phytosynthetic productivity requires both phosphorus and nitrogen, the optimal proportions of the two elements may vary considerably, depending on the kind of organism. Some of the weight ratios reported range from 11/1 for Selenastrum capricornutum (grown in culture medium; Miller, 1973) to 60/1 for Microcystis aeruginosa (total N/total P; Gerloff and Skoog, 1957), but an inorganic weight ratio of about 15/1 is frequently reported (e.g., Middlebrooks et.al., 1971; Schindler, 1971; Vollenweider, 1968; Vollenweider and Dillon, 1974). Considering the apparent co-limitation at 13/1 noted above and the 15/1 ratio, the NES selected an inorganic N/P ratio of 14/1 as an approximation to determine the limiting nutrient at those sampling times when no algal assay samples were collected or when the assay results were suspect. Since one of the primary objectives of the Survey was to evaluate the need for control of phosphorus inputs to the water bodies, the selected N/P ratio is considered conservative.

In larger lakes, and particularly in reservoirs, the assessment of limiting nutrient was done on a station-by-station basis. In many such water bodies, marked nitrogen limitation occurred near point-source impacts and/or in major tributary embayments while the main partion of the water body was phosphorus-limited.

Also, for some water bodies in which phosphorus and nitrogen levels were relatively high but chlorophyll a levels, phytoplankton numbers, and transparency were low, the possibility of light limitation was indicated.

We have not attempted a comparison of the NES assessment of limiting nutrient with those of others since N/P ratios reported to be limiting vary widely, as noted above.

D. Tributary Nutrient Levels -

Before comparing the NES stream nutrient data, it is useful to evaluate variances that occur in the measurement of nutrients and other parameters in streams. For this purpose, we retrieved from STORET (EPA's Storage and Retrieval computer system) data collected over varying periods of time by the U.S. Geological Survey at five hydrologic bench-mark stream sampling stations, two National stream-quality accounting network stations, and three sampling stations on other streams. The sampling stations were selected to illustrate variances in stream quality in various parts of the conterminous United States.

In water-data reports (e.g., Anonymous, 1976), the Geological Survey defines a hydrologic bench-mark station as "...one that provides hydrologic data for a basin in which the hydrologic regimen will likely be governed solely by natural conditions. Data collected... may be used to separate effects of natural from manmade changes in other basins that have been developed...". In the same publications, the objectives of National stream-quality accounting network stations are stated as "... (1) to depict areal variability of water-quality conditions... on a year-by-year basis and (2) to detect and assess long-term changes in stream quality".

The National network stations are on the Colorado River above Imperial Dam, Arizona and California, and the Missouri River at Pierre, South Dakota.

The bench-mark stations are:

Castle Creek, South Dakota
Elder Creek, California
Esopus Creek, New York
Upper Three Runs, South Carolina
Wet Bottom Creek, Arizona

The other stream stations include the Hudson River at Green Island, New York; The North Branch Potomac River near Cumberland, Maryland; and the Willamette River at Salem, Oregon. These streams were selected not only to demonstrate geographical differences but also to represent some differences in point-source impacts. For example, the Willamette River receives treated domestic wastes and a variety of treated industrial wastes upstream from the sampling station, whereas the North Branch Potomac River station is far upstream in the ridge and valley province of the Appalachian Mountains and has relatively little point-source impact, if any.

The data for the ten stations are presented on the following pages as reproductions of portions of the STORET data retrievals. Parameters of particular interest, represented by at least 15 samples, are indicated by double-pointed arrows in the space to the left of the column headed "Number".

Beginning with "Number" (of samples), the column headings are "Mean" ($\bar{x}$), "Variance" (s^2), "Stan Dev" (s), "Coef Var" (V; coefficients shown multiplied by 100 are equivalent to V values in percent elsewhere in this report), "Stan Er" (standard error of the mean), "Maximum" and "Minimum" (range of values), and "Beg Date" (beginning date) and "End Date" (ending date) is the period of record.

The ten-stream data indicate stream parameters are at least as variable as the lake parameters previously examined, if not more so. Further, the greater variability of nutrient parameters as compared to more-conservative parameters (e.g., conductivity, alkalinity, and dissolved calcium) is evident. This is more easily seen in the following tabulation of the coefficients of variation (X 100) of three nutrient parameters and one conservative parameter for the five bench-mark stations.

Coefficients of Variation

Stream	Sol. Reactive P (Ortho PO4)	Total P	Nitrite + Nitrate	Conductivity
Castle Cr.	154	69	64	10
Elder Cr.	133	132	145	22
Esopus Cr.	-	125	58	19
Upper Three Runs	-	172	18	27
Wet Bottom Cr.	103	-	178	52

Considering the variability of the data, it would be expected that some between-year differences in nutrient parameters will occur. We have made a number of such comparisons using U.S. Geological Survey

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STORET  DATE 77/01/29
                                                                09429490
                                                                32 52 59.0 114 27 55.0  2
                                                                COLORADO R AB IMPERIAL D ARIZ-CA
                                                                06025 CALIFORNIA
                                                                                        110191
/TYPA/AMBNT/STREAM                                              112WRD             04001004
                                                                 0000  CLASS 00

PARAMETER                                      NUMBER    MEAN  VARIANCE STAN DEV COEF VAR STAND ER  MAXIMUM   MINIMUM  BEG DATE END DATE
00008   LAB       IDENT.       NUMBER              10  603468 .100E+12    317686  .526433   100461   760195   223.000 73/07/18 75/08/05
00010  WATER       TEMP         CENT              133 20.4420  42.9330  6.55233  .320533  .568159  30.0000   1.80000 71/10/14 76/11/22
00020   AIR        TEMP         CENT               71 30.6478  616.505  24.8295  .810156  2.94672  225.000   12.0000 71/10/15 76/11/22
00060  STREAM      FLOW         CFS               238 8233.08  6729745  2594.18  .315091  168.155  12800.0   1140.00 71/10/06 76/11/29
00061  STREAM      FLOW.      INST-CFS             97 8315.94  7645568  2765.06  .332502  280.749  13300.0   2140.00 72/10/19 76/11/22
00070   TURB       JKSN         JTU                63 1.58570  .497723  .705495  .444911  .088884  4.00000   .999999 73/12/03 75/06/09
00076   TURB     TRBIDMTR     HACH FTU             96 5.12496  160.741  12.6784  2.47385  1.29398  120.000   .999999 75/02/03 76/11/29
00095 CNDUCTVY    AT 25C      MICROMHO            314 1332.76  6555.14  92.4940  .069400  5.21974  1730.00   1070.00 71/10/06 76/11/29
00300    DO                     MG/L               52 8.67110  .763308  .873675  .100757  .121157  10.7000   7.40000 71/10/15 76/11/10
00340   COD      HI LEVEL       MG/L               60 11.1667  40.6159  6.37306  .570722  .822759  36.0000   .000000 74/05/15 76/11/22
00400    PH                      SU               262 8.08270  .027404  .165540  .020481  .010227  8.39999   7.10000 71/10/06 76/11/29
00405   CO2                     MG/L              199 2.62053  4.00069  2.00017  .763269  .141789  26.0000   1.20000 72/07/12 76/11/29
00410  T ALK       CACO3        MG/L              230 146.357  64.4017  8.02507  .054832  .529157  182.000   113.000 71/10/06 76/11/29
00440 HCO3 ION     HCO3         MG/L              230 178.454  96.0611  9.80108  .054922  .646264  222.000   138.000 71/10/06 76/11/29
00445 CO3 ION       CO3         MG/L              225 .008889  .017778  .133333  15.0000  .008889  2.00000   .000000 71/10/06 76/11/29
00515 RESIDUE    DISS-105     C MG/L               10 927.000  3269.00  57.1752  .061678  18.0804 1000.000   840.000 71/10/18 76/07/14
00530 RESIDUE    TOT NFLT       MG/L               65 24.9231  1700.98  41.2429  1.65481  5.11555  265.000   .000000 71/10/18 76/11/22
00550 OIL-GRSE   TOT-SXLT       MG/L                3 .666667  1.33333  1.15470  1.73205  .666667  2.00000   .000000 74/05/15 74/07/10
00572 BIOMASS    PERPHYTN      G/SQ M               8 4.60912  61.7917  7.86077  1.70548  2.77920  23.0000   .200000 74/11/05 76/09/15
00573 BIOMASS    PERPHYTN     DW G/M2               7 7.06714  81.2211  9.01228  1.27524  3.40632  26.0000   .300000 75/02/11 76/09/15
00600 TOTAL N        N          MG/L               60 .563497  .070982  .266425  .472806  .034395  2.20000   .140000 74/05/15 76/11/22
00605  ORG N         N          MG/L               59 .363219  .034771  .186471  .513385  .024276  1.20000   .020000 74/05/15 76/11/22
00610  NH3-N       TOTAL        MG/L               59 .025593  .001080  .032867  1.28422  .004279  .210000   .000000 74/05/15 76/11/22
00613  NO2-N        DISS        MG/L               70 .002857  .000021  .004550  1.59256  .000544  .010000   .000000 72/11/01 76/11/10
00615  NO2-N       TOTAL        MG/L               57 .005789  .000032  .005653  .976406  .000749  .020000   .000000 74/05/15 76/11/22
00618  NO3-N        DISS        MG/L              104 .227497  .034734  .186372  .819227  .018275  1.80000   .050000 72/11/01 76/11/29
00620  NO3-N       TOTAL        MG/L               57 .174035  .016003  .126503  .726883  .016756  .980001   .030000 74/05/15 76/11/22
00625 TOT KJEL       N          MG/L               60 .388498  .033733  .183665  .472756  .023711  1.20000   .030000 74/05/15 76/11/22
00630 NO2&NO3    N-TOTAL        MG/L               60 .175000  .016158  .127112  .726358  .016410  1.00000   .010000 74/05/15 76/11/22
00631 NO2&NO3     N-DISS        MG/L               92 .285540  .242883  .492831  1.72596  .051381  4.60000   .060000 71/10/06 76/11/10
00660 ORTHOPO4      PO4         MG/L               85 .023765  .001340  .036612  1.54060  .003971  .250000   .000000 71/10/06 76/11/10
00665 PHOS-TOT                 MG/L P              59 .034068  .002718  .052131  1.53022  .006787  .360000   .000000 74/05/15 76/11/22
00666 PHOS-DIS                 MG/L P              11 .007273  .000102  .010091  1.38744  .003042  .030000   .000000 74/05/15 76/11/10
00671 PHOS-DIS     ORTHO       MG/L P              85 .007882  .000143  .011962  1.51752  .001297  .080000   .000000 71/10/06 76/11/10
00680 T ORG C        C          MG/L               58 5.33619  26.7186  5.16900  .968668  .678723  38.0000   2.20000 74/05/15 76/11/22
00900 TOT HARD     CACO3        MG/L              230 368.693  249.362  15.7912  .042830  1.04124  439.999   298.000 71/10/06 76/11/29
00902 NC HARD      CACO3        MG/L              231 222.209  101.313  10.0654  .045297  .662257  258.000   164.000 71/10/06 76/11/29
00915 CALCIUM     CA,DISS       MG/L              230 94.0361  25.7554  5.07498  .053968  .334634  114.000   79.0000 71/10/06 76/11/29
00916 CALCIUM     CA-TOT        MG/L               10 90.1000  166.326  12.8968  .143138  4.07831  120.000   69.0000 74/05/15 76/11/10
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STORET  DATE 77/03/15
                                                                      06440000
                                                                      44 22 25.0 100 22 20.0  2
                                                                      MISSOURI RIVER AT PIERRE S DAK
                                                                      46117 SOUTH DAKOTA
                                                                                                    090491
/TYPA/AMBNT/STREAM
                                                                      112WRD                 04001004
                                                                       0000  CLASS 00

PARAMETER
                                                  NUMBER     MEAN  VARIANCE  STAN DEV  COEF VAR  STAND ER   MAXIMUM   MINIMUM  BEG DATE  END DATE
00010  WATER       TEMP        CENT                   84  10.5642   46.5701   6.82423   .645975   .744584   22.0000   .000000  72/08/29  76/10/14
00020   AIR        TEMP        CENT                   14  10.4143   160.018   12.6498   1.21466   3.38080   26.4000-.179E+02  72/08/29  73/09/19
00060  STREAM      FLOW         CFS                   57  34820.5 .149E+09   12222.4   .351012   1618.90   54199.9   .050000  71/07/22  73/09/30
00061  STREAM      FLOW.     INST-CFS                 55  43129.0 .165E+09   12880.2   .298643   1736.77   57800.0   10800.0  73/10/16  76/10/14
00070   TURB       JKSN         JTU                   23  2.65217   2.69171   1.64064   .618603   .342097   7.00000   1.00000  74/05/10  76/09/29
00095 CNDUCTVY    AT 25C     MICROMHO                111  733.404   1739.05   41.7020   .056861   3.95817   870.000   648.000  71/07/22  76/10/14
00300   DO                     MG/L                   19  11.5210   3.76625   1.94068   .168447   .445223   14.4000   7.99999  72/08/29  74/01/10
00310   BOD       5 DAY        MG/L                   18  .883332   .039118   .197784   .223906   .046618   1.20000   .599999  72/08/29  74/01/10
00400   PH                      SU                   111  8.24587   .144496   .380126   .046099   .036080   10.2000   7.40000  71/07/22  76/10/14
00405   CO2                    MG/L                   83  2.20602   2.72686   1.65132   .748552   .181256   12.0000   .200000  71/07/22  76/10/14
00410  T ALK      CACO3        MG/L                   94  156.191   44.2581   6.65267   .042593   .686171   173.000   126.000  71/07/22  76/10/14
00440 HCO3 ION     HCO3        MG/L                   94  188.606   77.8279   8.82201   .046775   .909921   211.000   154.000  71/07/22  76/10/14
00445 CO3 ION      CO3         MG/L                   91  .956044   5.22027   2.28479   2.38984   .239511   11.0000   .000000  71/07/31  76/10/14
00572 BIOMASS    PERPHYTN    G/SQ M                    6  .780833   .718518   .847654   1.08558   .346053   2.30000   .077000  74/11/04  76/09/29
00573 BIOMASS    PERPHYTN   DW G/M2                    5  1.20680   1.13707   1.06634   .883607   .476880   2.40000   .154000  75/07/08  76/09/29
00600 TOTAL N        N         MG/L                   41  .476340   .051145   .226154   .474773   .035319   1.40000   .120000  72/08/29  76/09/29
00605  ORG N         N         MG/L                   17  .235882   .022563   .150211   .636805   .036432   .640001   .070000  72/08/29  74/01/10
00608  NH3-N        DISS       MG/L                    6  .028333   .000337   .018349   .647595   .007491   .060000   .010000  72/08/29  73/01/10
00610  NH3-N       TOTAL       MG/L                   13  .036923   .001190   .034493   .934177   .009567   .140000   .000000  72/12/04  74/01/10
00613  NO2-N        DISS       MG/L                   17  .002353   .000019   .004372   1.85826   .001060   .010000   .000000  72/08/29  74/01/10
00618  NO3-N        DISS       MG/L                   17  .298235   .056790   .238307   .799058   .057798   .930001   .130000  72/08/29  74/01/10
00625 TOT KJEL       N         MG/L                   41  .281951   .016476   .128359   .455254   .020046   .660001   .000000  72/08/29  76/09/29
00630 NO2&NO3     N-TOTAL      MG/L                   35  .165714   .021107   .145283   .876709   .024557   .920001   .050000  73/02/27  76/09/29
00631 NO2&NO3      N-DISS      MG/L                   73  .220411   .018818   .137178   .622374   .016055   .940001   .040000  71/07/22  76/10/14
00660 ORTHOPO4      PO4        MG/L                   68  .034412   .001324   .036380   1.05721   .004412   .150000   .000000  71/08/25  76/10/14
00665 PHOS-TOT                MG/L P                  92  .042065   .007351   .085736   2.03818   .008939   .800001   .000000  71/07/22  76/10/14
00666 PHOS-DIS                MG/L P                  59  .019830   .000502   .022399   1.12951   .002916   .150000   .000000  71/12/31  76/10/14
00671 PHOS-DIS     ORTHO      MG/L P                  68  .011471   .000147   .012127   1.05721   .001471   .050000   .000000  71/08/25  76/10/14
00680 T ORG C        C         MG/L                    9  4.44444   6.86780   2.62065   .589646   .873549   11.0000   2.20000  74/10/04  76/07/27
00900 TOT HARD     CACO3       MG/L                   94  193.808   5082.19   71.2895   .367835   7.35295   260.000   5.00000  71/07/22  76/10/14
00902 NC HARD      CACO3       MG/L                   94  58.4148   758.122   27.5340   .471353   2.83992   95.0000   .000000  71/07/22  76/10/14
00915 CALCIUM     CA.DISS      MG/L                   94  46.7999   389.928   19.7466   .421936   2.03670   65.0000   .600000  71/07/22  76/10/14
00925 MGNSIUM     MG.DISS      MG/L                   94  18.7563   32.6182   5.71123   .304496   .589069   24.0000   .500000  71/07/22  76/10/14
00930  SODIUM     NA.DISS      MG/L                   94  85.1489   1978.65   44.4821   .522403   4.58797   240.000   56.0000  71/07/22  76/10/14
00931  SODIUM    ADSBTION      RATIO                  94  4.60421   61.1834   7.82198   1.69887   .806776   48.0000   1.70000  71/07/22  76/10/14
00932  PERCENT    SODIUM        %                     94  46.8829   376.562   19.4052   .413907   2.00149   98.0000   35.0000  71/07/22  76/10/14
00935 PTSSIUM     K.DISS       MG/L                   94  4.76378   .196927   .443764   .093154   .045771   7.20000   3.80000  71/07/22  76/10/14
00940 CHLORIDE      CL         MG/L                   94  9.92655   1.40104   1.18366   .119241   .122085   14.0000   7.90000  71/07/22  76/10/14
00945 SULFATE     SO4-TOT      MG/L                   94  201.702   156.237   12.4995   .061970   1.28922   230.000   170.000  71/07/22  76/10/14
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STORET  DATE 77/04/13

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                                                                    CASTLE CR ABV DEERFIELD RES, NR
                                                                    46103 SOUTH DAKOTA
                                                                                              090491
/TYPA/AMBNT/STREAM
                                                                    112WRD              0400100-
                                                                     0000   CLASS 00

PARAMETER
                                                NUMBER     MEAN   VARIANCE  STAN DEV  COEF VAR  STAND ER   MAXIMUM   MINIMUM  BEG DATE END DATE
00008   LAB          IDENT.       NUMBER             2   376087  .281E+12    530414   1.41035    375060    751146   1027.00  73/11/26 74/10/15
00010  WATER          TEMP          CENT           191  5.36831   30.3435   5.50850   1.02611   .398581   18.5000-.100E+01  64/12/31 76/12/13
00020   AIR           TEMP          CENT            63  9.64275   115.511   10.7476   1.11458   1.35407   33.5000-.115E+02  68/10/14 76/07/23
00060  STREAM         FLOW          CFS            146  12.8707   22.9405   4.78962   .372132   .396392   42.0000   2.10000  64/12/31 73/09/25
00061  STREAM         FLOW,      INST-CFS           91  11.4988   19.1527   4.37638   .380596   .458769   34.0000   2.10000  69/10/27 76/12/13
00063  NO. OF       SAMPLING      POINTS             2  8.00000   2.00000   1.41421   .176777   1.00000   9.00000   7.00000  67/09/19 68/04/25
00065  STREAM         STAGE         FEET            19  2.22684   3.47690   1.86464   .837352   .427779   6.00000  .499E-06  69/11/18 71/11/16
00080  COLOR          PT-CO        UNITS            27  6.00000   15.0770   3.88291   .647151   .747266   17.0000   1.00000  65/03/10 71/04/12
00095 CNDUCTVY        AT 25C      MICROMHO         175  462.077   2302.34   47.9828   .103842   3.62716   639.999   304.000  64/12/31 76/12/13
00300    DO                        MG/L             88  10.0079   1.99506   1.41247   .141135   .150569   13.1000   6.00000  67/09/19 75/06/10
00310   BOD           5 DAY        MG/L             82  .989384   .262606   .512451   .517949   .056591   3.40000   .100000  67/10/22 73/09/25
00400    PH                         SU             171  8.22212   .182238   .426893   .051920   .032645   9.69999   6.60000  64/12/31 76/12/13
00405   CO2                        MG/L             53  3.31131   10.2960   3.20874   .969023   .440754   21.0000   .100000  71/03/09 76/12/13
00410  T ALK          CACO3        MG/L            112  245.332   456.594   21.3681   .087098   2.01909   288.000   182.000  65/05/16 76/12/13
00440 HCO3 ION         HCO3        MG/L            123  297.715   764.541   27.6503   .092875   2.49315   351.000   180.000  64/12/31 76/12/13
00445 CO3 ION          CO3         MG/L            113  .734514   9.57175   3.09383   4.21207   .291043   22.0000   .000000  64/12/31 76/12/13
00515 RESIDUE       DISS-105     C MG/L             13  273.077   1889.78   43.4716   .159192   12.0568   390.000   220.000  67/09/19 75/10/16
00530 RESIDUE       TOT NFLT       MG/L             13  8.38461   88.5896   9.41221   1.12256   2.61048   29.0000  1.000000  67/09/19 75/10/16
00615  NO2-N          TOTAL        MG/L              1  .050000                                         .050000   .050000  71/03/09 71/03/09
00618  NO3-N           DISS        MG/L             31  .129032   .014702   .121253   .939715   .021778   .410000   .000000  68/10/14 71/04/12
00630 NO2&NO3        N-TOTAL       MG/L             38  .155263   .014723   .121338   .781504   .019684   .630001   .010000  73/11/26 76/12/13
00631 NO2&NO3        N-DISS        MG/L             31  .132580   .008627   .092879   .700549   .016682   .320000   .000000  71/05/11 76/09/14
00650  T PO4           PO4         MG/L             20  .184000   .038615   .196506   1.06797   .043940   .560000  .499E-06  65/05/16 68/09/18
00660 ORTHOPO4         PO4         MG/L             59  .047966   .005458   .073877   1.54020   .009618   .480000   .000000  67/10/22 73/10/30
00665 PHOS-TOT                     MG/L P           70  .038000   .000744   .027272   .717695   .003260   .140000   .000000  70/11/16 76/12/13
00666 PHOS-DIS                     MG/L P           48  .039667   .002074   .045544   1.14817   .006574   .270001   .000000  68/10/14 73/10/30
00671 PHOS-DIS        ORTHO        MG/L P           27  .010000   .000131   .011435   1.14354   .002201   .040000   .000000  70/05/11 73/10/30
00680 T ORG C           C          MG/L              3  25.1666   1255.58   35.4341   1.40798   20.4579   65.9999   2.50000  68/09/18 73/11/26
00720 CYANIDE        CN-TOT        MG/L              8  .006250   .000198   .014079   2.25262   .004978   .040000   .000000  73/11/26 76/10/20
00900 TOT HARD        CACO3        MG/L            123  250.764   449.541   21.2024   .084551   1.91175   291.000   186.000  64/12/31 76/12/13
00902 NC HARD         CACO3        MG/L            123  6.67885   68.5184   8.27758   1.23937   .746365   48.0000   .000000  64/12/31 76/12/13
00915 CALCIUM        CA,DISS       MG/L            123  52.4551   57.9155   7.61022   .145081   .686190   66.0000   25.0000  64/12/31 76/12/13
00925 MGNSIUM        MG,DISS       MG/L            123  29.1869   4.75973   2.18168   .074748   .196716   40.0000   20.0000  64/12/31 76/12/13
00930  SODIUM        NA,DISS       MG/L            123  1.86422   .635078   .796918   .427480   .071856   6.70000   .500000  64/12/31 76/12/13
00931  SODIUM       ADSBTION      RATIO            112  .050000   .002703   .051988   1.03976   .004912   .200000   .000000  64/12/31 76/12/13
00932  PERCENT       SODIUM          %             121  1.52066   .501658   .708278   .465770   .064389   5.00000  .499E-06  65/05/16 76/12/13
00935 PTSSIUM        K,DISS        MG/L            123  1.50894   .431146   .656617   .435152   .059205   5.10000   .700000  64/12/31 76/12/13
00940 CHLORIDE         CL          MG/L            122  1.46475   .980630   .990268   .676067   .089655  10.00000   .400000  64/12/31 76/12/13
00945 SULFATE       SO4-TOT        MG/L            123  7.38692   7.19307   2.68199   .363073   .241827   22.0000   .300000  64/12/31 76/12/13
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STORET  DATE 77/01/28
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                                                                                        140291
/TYPA/AMBNT/STREAM
                                                              112WRD             04001004
                                                               0000  CLASS 00

PARAMETER                                 NUMBER     MEAN  VARIANCE  STAN DEV  COEF VAR  STAND ER   MAXIMUM   MINIMUM  BEG DATE END DATE
00004  STREAM    WIDTH       FEET              12  22.9666   96.0415   9.80008   .426710   2.82904   36.0000   3.50000  73/10/04 74/09/03
00008   LAB      IDENT.      NUMBER             4   755954  .300E+08   5482.62   .007253   2741.31    760837    751067  74/10/14 75/09/22
00010  WATER      TEMP       CENT             159  10.4999   13.1307   3.62363   .345113   .287373   20.5000   2.50000  68/06/14 76/09/16
00020   AIR       TEMP       CENT              17  12.9412   30.9964   5.56744   .430211   1.35030   24.5000   5.99999  70/01/21 75/07/18
00060  STREAM     FLOW       CFS               80  45.3070   8957.49   94.6440   2.08895   10.5815   556.000   .500000  68/02/15 71/09/21
00061  STREAM     FLOW,     INST-CFS           91  73.1465   20322.7   142.558   1.94893   14.9441   647.999   .669999  71/10/18 76/09/16
00063  NO. OF   SAMPLING     POINTS             4  4.00000   8.66664   2.94392   .735980   1.47196   7.99999   1.00000  69/11/21 74/01/17
00075   TURB      HLGE     PPM SIO2             1  2.00000                                           2.00000   2.00000  68/02/15 68/02/15
00080  COLOR     PT-CO       UNITS              2  3.50000   4.50000   2.12132   .606091   1.50000   5.00000   2.00000  68/06/14 70/02/19
00095 CNDUCTVY   AT 25C    MICROMHO  ↔         93  107.577   546.609   23.3797   .217329   2.42436   158.000   48.9999  68/02/15 76/09/16
00300    DO                  MG/L              80  10.5736   1.10517   1.05127   .099424   .117536   13.3000   8.20000  68/06/14 76/09/16
00301    DO      SATUR     PERCENT             57  97.5935   25.7288   5.07236   .051974   .671850   108.000   80.0000  68/06/14 76/09/16
00310   BOD      5 DAY       MG/L              24  .724999   .953264   .976353   1.34669   .199297   3.60000  .499E-06  68/06/14 71/06/14
00400    PH                   SU               99  7.47264   .176459   .420070   .056214   .042219   8.70000   6.30000  68/02/15 76/08/10
00405   CO2                  MG/L              41  4.48048   14.7926   3.84611   .858415   .600662   16.0000   .600000  71/10/19 76/08/10
00410  T ALK     CACO3       MG/L    ↔         89  49.0364   109.111   10.4456   .213018   1.10723   69.0000   25.0000  68/02/15 76/09/16
00440 HCO3 ION    HCO3       MG/L              75  60.5199   169.959   13.0368   .215414   1.50537   84.0000   30.0000  68/02/15 76/09/16
00445 CO3 ION     CO3        MG/L              69 .144E-06  .522E-13  .228E-06   1.57672  .275E-07  .499E-06   .000000  68/02/15 76/08/10
00515 RESIDUE  DISS-105    C MG/L              13  74.1537   166.823   12.9160   .174179   3.58225   88.0000   49.0000  68/03/14 76/01/26
00530 RESIDUE  TOT NFLT      MG/L              13  1.61538   2.75641   1.66024   1.02777   .460468   7.00000  1.000000  68/03/14 76/01/26
00600 TOTAL N       N        MG/L              10  .420000   .168934   .411016   .978608   .129975   1.50000   .070000  68/10/02 73/02/22
00605  ORG N        N        MG/L              27  .285926   .136802   .369868   1.29358   .071181   1.50000   .000000  68/06/14 73/02/22
00608  NH3-N      DISS       MG/L               6  .036667   .001187   .034448   .939491   .014063   .080000   .000000  71/05/25 73/02/22
00610  NH3-N      TOTAL      MG/L               3  .036667   .001033   .032146   .876696   .018559   .060000   .000000  73/01/17 75/07/18
00615  NO2-N      TOTAL      MG/L              28  .003929   .000047   .006853   1.74429   .001295   .020000   .000000  74/01/22 76/09/16
00620  NO3-N      TOTAL      MG/L              28  .039643   .004129   .064261   1.62100   .012144   .270000   .000000  74/01/22 76/09/16
00625 TOT KJEL      N        MG/L    ↔         16  .180000   .031333   .177012   .983402   .044253   .580000   .000000  69/10/23 73/02/22
00630 NO2&NO3   N-TOTAL      MG/L    ↔         30  .042333   .003750   .061233   1.44646   .011180   .270000   .000000  73/01/17 76/09/16
00631 NO2&NO3    N-DISS      MG/L    ↔         49  .031224   .005194   .072071   2.30818   .010296   .430000   .000000  71/05/25 76/08/10
00650  T PO4      PO4        MG/L              25  .176400   .035024   .187147   1.06092   .037429   .990000   .060000  68/02/15 71/02/09
00653 SOLPO4-T    PO4        MG/L               1  .070000                                           .070000   .070000  70/02/19 70/02/19
00660 ORTHOPO4    PO4        MG/L    ↔         29  .121724   .026300   .162174   1.33231   .030115   .860000   .000000  68/06/14 73/02/22
00665 PHOS-TOT               MG/L P  ↔         49  .048979   .004172   .064590   1.31872   .009227   .450000   .000000  71/05/25 76/09/16
00671 PHOS-DIS   ORTHO       MG/L P             6  .040000   .000560   .023664   .591608   .009661   .080000   .010000  71/05/25 73/02/22
00680 T ORG C      C         MG/L               2  2.50000   4.49998   2.12132   .848527   1.50000   4.00000  1.000000  72/07/18 73/10/04
00720 CYANIDE    CN-TOT      MG/L               6  .000000   .000000   .000000             .000000   .000000   .000000  74/06/19 76/09/16
00900 TOT HARD   CACO3       MG/L              76  42.2631   85.9558   9.27124   .219369   1.06348   62.0000   21.0000  68/02/15 76/09/16
00902 NC HARD    CACO3       MG/L              76  .802631   45.7872   6.76662   8.43055   .776185   59.0000   .000000  68/02/15 76/09/16
00915 CALCIUM   CA-DISS      MG/L    ↔         76  11.1302   6.25448   2.50090   .224694   .286872   16.0000   5.40000  68/02/15 76/09/16
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STOCK FORM NO. 61411

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STORET  DATE 77/01/28
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                                                            36111 NEW YORK
                                                                                  013292
/TYPA/AMBNT/STREAM
                                                            112WRD            04001004
                                                             0000  CLASS 00

PARAMETER                                    NUMBER    MEAN  VARIANCE STAN DEV COEF VAR STAND ER MAXIMUM   MINIMUM  BEG DATE END DATE
00008   LAB        IDENT.     NUMBER             16   213463 .715E+12   844409  3.95577   211102  3379993  332.000 71/03/23 73/10/18
00010  WATER        TEMP       CENT             132  8.91657  49.0658  7.00470  .785582  .609681  26.5000  .000000 66/11/15 76/09/22
00020   AIR         TEMP       CENT              89  12.6740  103.327  10.1650  .802036  1.07749  28.0000-.149E+02 69/01/29 76/09/22
00060  STREAM       FLOW       CFS              100  141.118  32145.3  179.291  1.27050  17.9291  1040.00  4.40000 63/08/20 74/03/26
00061  STREAM       FLOW,     INST-CFS           55  147.649  31288.6  176.886  1.19802  23.8513  1160.00  5.49999 72/10/05 76/09/22
00065  STREAM       STAGE      FEET              58  7.74199  387.349  19.6812  2.54213  2.58427  155.000  4.15000 68/10/31 74/03/26
00075   TURB        HLGE      PPM SIO2            7  .600000  .110000  .331663  .552772  .125357 1.000000  .000000 63/08/20 65/02/16
00080  COLOR        PT-CO      UNITS             60  4.34998  65.4171  8.08808  1.85934  1.04417  55.0000  .000000 63/08/20 71/05/25
00095 CNDUCTVY     AT 25C     MICROMHO          131  53.6097  99.4115  9.97053  .18598   .871129  100.000  37.0000 63/08/20 76/09/22
00300    DO                    MG/L             110  11.4526  3.85765  1.96409  .171497  .187269  16.6000  4.60000 67/09/19 76/09/22
00301    DO        SATUR      PERCENT            54  98.7406  101.187  10.0592  .101875  1.36888  113.000  53.0000 69/11/06 76/09/22
00310   BOD        5 DAY       MG/L              60  .867829  .723787  .850757  .980327  .109832  4.00000  .000000 67/10/25 73/09/11
00400    PH                     SU              129  7.03789  .141693  .376421  .053485  .033142  8.70000  6.19999 63/08/20 76/09/22
00405   CO2                    MG/L              51  2.83333  9.05384  3.00896  1.06199  .421339  12.0000  .100000 72/01/26 76/09/22
00410  T ALK       CACO3       MG/L             118  10.7542  16.1700  4.02119  .373917  .370180  21.0000  2.00000 64/03/31 76/09/22
00440 HCO3 ION      HCO3       MG/L             120  13.1741  24.2362  4.92303  .373691  .449409  25.0000  2.40000 63/08/20 76/09/22
00445 CO3 ION       CO3        MG/L             110 .109E-06 .430E-13 .207E-06  1.90164 .197E-07 .499E-06  .000000 64/10/27 76/09/22
00505 RESIDUE     TOT VOL      MG/L              22  5.77272  17.8030  4.21936  .730915  .899571  14.0000  .000000 69/06/26 71/05/25
00515 RESIDUE     DISS-105   C MG/L              12  39.1666  569.430  23.8627  .609263  6.88858  110.000  19.0000 67/09/19 75/10/20
00530 RESIDUE     TOT NFLT     MG/L              12  11.4167  771.354  27.7733  2.43270  8.01745  98.0000  .999999 67/09/19 75/10/20
00605  ORG N          N        MG/L              27  .113704  .072478  .269218  2.36771  .051811  1.40000  .000000 68/08/07 71/02/19
00608  NH3-N        DISS       MG/L               3  .076667  .001733  .041633  .543044  .024037  .110000  .030000 71/07/01 73/07/17
00610  NH3-N        TOTAL      MG/L               1  .000000                                       .000000  .000000 72/01/26 72/01/26
00613  NO2-N        DISS       MG/L               6  .006667  .000046  .006802  1.02029  .002777  .018000  .000000 71/07/01 73/09/11
00615  NO2-N        TOTAL      MG/L               6  .004500  .000019  .004416  .981308  .001803  .010000  .000000 73/10/18 74/03/26
00618  NO3-N        DISS       MG/L              22  .179999  .017486  .132234  .734634  .028192  .500000  .000000 71/07/01 73/09/11
00620  NO3-N        TOTAL      MG/L              13  .369999  .027667  .166333  .449549  .052599  .599999  .010000 72/01/26 74/03/26
00630 NO2&NO3     N-TOTAL      MG/L              34  .231235  .018112  .134582  .582015  .023081  .519999  .010000 73/10/18 76/09/22
00631 NO2&NO3      N-DISS      MG/L               3  .246666  .009733  .098658  .399964  .056960  .360000  .180000 73/05/30 73/09/11
00650  T PO4         PO4       MG/L               4  .070000  .005400  .073485  1.04978  .036742  .180000  .030000 72/06/06 72/09/07
00660 ORTHOPO4       PO4       MG/L               1  .020000                                       .020000  .020000 72/10/05 72/10/05
00665 PHOS-TOT                MG/L P             64  .015359  .000370  .019241  1.25275  .002405  .140000  .000000 70/11/24 76/09/22
00666 PHOS-DIS                MG/L P              1  .000000                                       .000000  .000000 71/10/01 71/10/01
00680 T ORG C         C        MG/L               2  .250000  .125000  .353553  1.41421  .250000  .500000  .000000 72/09/07 73/10/18
00720 CYANIDE      CN-TOT      MG/L               3  .000000  .000000  .000000           .000000  .000000  .000000 74/05/15 76/07/09
00900 TOT HARD     CACO3       MG/L             119  18.7406  11.7478  3.42750  .182892  .314199  27.0000  12.0000 63/08/20 76/09/22
00902 NC HARD      CACO3       MG/L             119  7.85709  4.97130  2.22964  .283774  .204391  13.0000  1.00000 63/08/20 76/09/22
00915 CALCIUM     CA-DISS      MG/L             120  5.54325  1.34129  1.15814  .208928  .105723  9.00000  3.20000 63/08/20 76/09/22
00925 MGNSIUM     MG-DISS      MG/L             120  1.21583  .056816  .238360  .196048  .021759  2.30000  .800000 63/08/20 76/09/22
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STOCK FORM NO. 61411

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STORET  DATE 77/01/28

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                                                                       UPPER THREE RUNS NR NEW ELLENTON
                                                                       45003 SOUTH CAROLINA
                                                                                                 031391
/TYPA/AMBNT/STREAM
                                                                       112*RD                0400100
                                                                        0000  CLASS 00

PARAMETER                                        NUMBER      MEAN  VARIANCE  STAN DEV  COEF VAR  STAND ER   MAXIMUM   MINIMUM  BEG DATE END DATE
00008    LAB      IDENT.     NUMBER                   2    376267 .281E+12    530868   1.41088    375381    751647   886.000  73/10/29 74/11/27
00010   WATER      TEMP       CENT                  156   15.9530  15.7980   3.97467   .249148   .318228   23.0000   8.99999  67/11/02 76/12/03
00060   STREAM     FLOW       CFS                   133   119.065  1194.14   34.5563   .290230   2.99641   229.000   77.9999  67/11/02 73/09/21
00061   STREAM     FLOW.    INST-CFS                 54   155.147  3951.55   62.8613   .405174   8.55434   549.999   106.000  72/10/24 76/12/03
00080   COLOR      PT-CO     UNITS                   56   10.1428  71.2892   8.44329   .832442   1.12828   40.0000   2.00000  67/11/02 73/10/29
00095 CNDUCTVY    AT 25C    MICROMHO                136   15.8742  17.9512   4.23688   .266904   .363310   49.9999   12.0000  67/11/02 76/11/11
00300     DO                  MG/L                   80   9.27117  1.50208   1.22559   .132194   .137025   11.8000   6.70000  67/11/02 76/11/11
00301     DO       SATUR    PERCENT                   1   97.0000                                          97.0000   97.0000  68/08/05 68/08/05
00310    BOD       5 DAY      MG/L                   10   3.70000  106.280   10.3092   2.78628   3.26006   33.0000  .499E-06  68/10/07 71/06/11
00400     PH                   SU                   129   5.89844  .269562   .519193   .089386   .045712   7.60000   4.40000  67/11/02 76/11/11
00405    CO2                  MG/L                   28   5.43214  39.1704   6.25863   1.15215   1.18277   32.0000   .000000  72/10/24 76/11/11
00410   T ALK      CACO3      MG/L                   76   2.38158  1.19913   1.09505   .459799   .125611   6.00000   .000000  67/11/02 76/11/11
00440 HCO3 ION     HCO3       MG/L                   76   2.93420  2.00892   1.41736   .483048   .162583   7.00000   .000000  67/11/02 76/11/11
00445 CO3 ION      CO3        MG/L                   74  .189E-06 .596E-13  .244E-06   1.29049  .283E-07  .499E-06   .000000  67/11/02 76/11/11
00515 RESIDUE    DISS-105   C MG/L                   13   19.1538  36.1416   6.01179   .313869   1.66737   35.0000   11.0000  67/11/02 75/11/18
00530 RESIDUE    TOT NFLT     MG/L                   13   4.53846  11.9359   3.45484   .761237   .958200   12.0000   2.00000  67/11/02 75/11/18
00613  NO2-N       DISS       MG/L                    1   .020000                                          .020000   .020000  73/10/29 73/10/29
00615  NO2-N      TOTAL       MG/L                    5   .014000  .000666   .025807   1.84336   .011541   .060000   .000000  72/12/12 73/06/21
00618  NO3-N       DISS       MG/L                    8   .083750  .003341   .057802   .690171   .020436   .200000   .020000  71/10/08 73/10/29
00620  NO3-N      TOTAL       MG/L                    5   .233999  .031180   .176579   .754613   .078968   .539999   .100000  72/12/12 73/06/21
00630 NO2&NO3    N-TOTAL      MG/L                   20   .198000  .001312   .036218   .182918   .008099   .270000   .110000  73/12/12 76/11/11
00631 NO2&NO3    N-DISS       MG/L                    1   .040000                                          .040000   .040000  73/10/29 73/10/29
00650   T PO4      PO4        MG/L                   17   .835885  11.5086   3.39243   4.05849   .822785   14.0000   .000000  67/11/02 70/07/01
00660 ORTHOPO4     PO4        MG/L                   10   .011000  .000388   .019692   1.79012   .006227   .060000   .000000  68/10/07 71/08/20
00665 PHOS-TOT               MG/L P                  43   .005861  .000102   .010080   1.71991   .001537   .060000   .000000  69/07/11 76/11/11
00666 PHOS-DIS               MG/L P                   1  .499E-06                                         .499E-06  .499E-06  69/09/05 69/09/05
00680 T ORG C       C         MG/L                    4   5.87500  45.7294   6.76235   1.15104   3.38118   16.0000   2.00000  68/12/04 73/10/29
00720 CYANIDE    CN-TOT       MG/L                    8   .000000  .000000   .000000             .000000   .000000   .000000  72/04/24 76/11/11
00900 TOT HARD    CACO3       MG/L                   76   2.97368  2.26596   1.50531   .506211   .172671   9.00000   1.00000  67/11/02 76/11/11
00902 NC HARD     CACO3       MG/L                   76   .947367  2.05053   1.43197   1.51152   .164258   7.00000   .000000  67/11/02 76/11/11
00915 CALCIUM    CA.DISS      MG/L                   76   .701312  .276401   .525739   .749651   .060306   3.00000   .100000  67/11/02 76/11/11
00925 MGNSIUM    MG.DISS      MG/L                   76   .298682  .013733   .117188   .392350   .013442   .600000   .000000  67/11/02 76/11/11
00930  SODIUM    NA.DISS      MG/L                   76   1.27105  .098360   .313624   .246744   .035975   3.40000   .200000  67/11/02 76/11/11
00931  SODIUM    ADSRTION    RATIO                   76   .342102  .016606   .128863   .376681   .014782   1.10000   .000000  67/11/02 76/11/11
00932  PERCENT    SODIUM       *                     76   47.1184  135.813   11.6539   .247332   1.33679   77.0000   5.00000  67/11/02 76/11/11
00935 PTSSIUM    K.DISS       MG/L                   76   .285524  .032455   .180154   .630958   .020665   1.40000   .100000  67/11/02 76/11/11
00940 CHLORIDE     CL         MG/L                   76   2.31578  .283724   .532657   .230012   .061100   3.70000   .200000  67/11/02 76/11/11
00945 SULFATE    SO4-TOT      MG/L                   76   .942136  .411266   .641300   .680687   .073562   3.00000   .000000  67/11/02 76/11/11
00950 FLUORIDE   F.DISS       MG/L                   75   .081333  .028836   .169812   2.08785   .019608   1.30000   .000000  67/11/02 76/11/11
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STORET  DATE 77/01/28
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                                                      WET BOTTOM CREEK NR CHILDS, ARI
                                                      04007 ARIZONA
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/TYPA/AMBNT/STREAM                                    112WRD            04001004
                                                       0000  CLASS 00

PARAMETER                                     NUMBER     MEAN  VARIANCE  STAN DEV  COEF VAR  STAND ER   MAXIMUM   MINIMUM  BEG DATE END DATE
00003    LAB      IDENT.    NUMBER                 4   563790  .140E+12    375225   .665540    187612    751403   952.000  73/11/14 74/11/14
00010  WATER       TEMP      CENT                109  14.6480   50.1759   7.08349   .483580   .678476   32.0000   .150000  68/02/27 76/10/12
00020    AIR       TEMP      CENT                  9  15.3333   94.9379   9.74361   .596549   3.24787   35.0000   8.50000  71/08/12 74/02/11
00060  STREAM      FLOW      CFS                  96  13.2995   1205.82   34.7249   2.61100   3.54409   176.000   .000000  68/02/27 75/07/24
00061  STREAM      FLOW.   INST-CFS               32  31.1980   2634.87   51.3309   1.64533   9.07411   176.000   .040000  72/10/05 76/10/12
00070   TURB       JKSN      JTU                   1  .999999                                         .999999   .999999  70/02/23 70/02/23
00075   TURB       HLGE    PPM SIO2                5  .680000   .087000   .294958   .433762   .131909   1.00000   .400000  69/11/12 70/10/15
00080  COLOR      PT-CO     UNITS                 19  8.26316   87.9827   9.37991   1.13515   2.15190   30.0000   3.00000  68/08/21 70/10/15
00095 CNDUCTVY    AT 25C   MICROMHO <------>      77  263.909   18602.2   136.390   .516806   15.5431   580.000   6.00000  68/08/21 76/10/12
00300    DO                  MG/L                 27  8.05925   2.08328   1.44336   .179093   .277774  10.00000   5.40000  68/08/21 74/02/11
00400    PH                  SU                   77  7.56485   .474404   .688770   .091049   .078493   8.70000   5.50000  68/08/21 76/10/12
00405   CO2                  MG/L                 32  3.61562   11.6665   3.41563   .944686   .603803   15.0000   .300000  70/02/23 76/10/12
00410  T ALK      CACO3      MG/L   <------>      65  115.031   4774.46   69.0975   .600686   8.57049   251.000   13.0000  68/08/21 76/10/12
00440 HCO3 ION     HCO3      MG/L                 66  137.424   7216.40   84.9494   .618155   10.4565   306.000   .000000  68/08/21 76/10/12
00445 CO3 ION      CO3       MG/L                 54  .425926   1.72082   1.31180   3.07988   .178514   6.00000   .000000  68/08/21 76/10/12
00515 RESIDUE   DISS-105   C MG/L                 11  182.454   8666.07   93.0917   .510219   28.0682   290.000   51.0000  68/01/29 75/11/14
00530 RESIDUE   TOT NFLT     MG/L                 11  3.18181   19.5636   4.42307   1.39011   1.33361   15.0000  1.000000  68/01/29 75/11/14
00613  NO2-N       DISS      MG/L                 18  .001111   .000022   .004714   4.24264   .001111   .020000   .000000  72/11/28 75/04/14
00618  NO3-N       DISS      MG/L                 19  .069474   .022528   .150092   2.16041   .034433   .680001   .000000  70/02/23 75/04/14
00631 NO2&NO3     N-DISS     MG/L  <------>       47  .079149   .019764   .140585   1.77622   .020506   .700001   .000000  70/12/15 76/10/12
00650  T PO4       PO4       MG/L                 14  .117143   .068868   .262427   2.24023   .070136   1.00000   .000000  68/08/21 70/10/15
00660 ORTHOPO4     PO4       MG/L  <------>       46  .041956   .001865   .043185   1.02929   .006367   .210000   .000000  70/12/15 76/10/12
00671 PHOS-DIS    ORTHO     MG/L P <------>       44  .013409   .000214   .014618   1.09016   .002204   .070000   .000000  71/03/30 76/10/12
00720 CYANIDE     CN-TOT     MG/L                  3  .003333   .000033   .005774   1.73205   .003333   .010000   .000000  74/12/13 76/10/12
00900 TOT HARD    CACO3      MG/L                 65  97.7077   2845.44   53.3427   .545942   6.61635   240.000   22.0000  68/08/21 76/10/12
00902 NC HARD     CACO3      MG/L                 65  1.84615   12.6322   3.55418   1.92518   .440842   13.0000   .000000  68/08/21 76/10/12
00915 CALCIUM    CA.DISS     MG/L  <------>       66  26.3515   219.274   14.8079   .561938   1.82272   62.0000   .000000  68/08/21 76/10/12
00925 MGNSIUM    MG.DISS     MG/L                 66  7.36965   18.5925   4.31191   .585090   .530759   20.0000   .000000  68/08/21 76/10/12
00930  SODIUM    NA.DISS     MG/L                 66  18.4318   115.512   10.7476   .583104   1.32294   40.0000   .000000  68/08/21 76/10/12
00931  SODIUM   ADSBTION     RATIO                65  .796919   .131244   .362276   .454596   .044935   2.50000   .200000  68/08/21 76/10/12
00932  PERCENT    SODIUM      %                   65  28.5231   37.6608   6.13684   .215153   .761181   65.0000   17.0000  68/08/21 76/10/12
00935 PTSSIUM     K.DISS     MG/L                 66  1.21212   .186629   .432006   .356406   .053176   2.30000   .000000  68/08/21 76/10/12
00940 CHLORIDE      CL       MG/L                 66  8.75149   28.8254   5.36893   .613488   .660870   30.0000   .000000  68/08/21 76/10/12
00945 SULFATE    SO4-TOT     MG/L                 66  9.12421   17.9825   4.24058   .464761   .521979   28.0000   .000000  68/08/21 76/10/12
00950 FLUORIDE    F.DISS     MG/L                 66  1.29393   .452589   .672747   .519924   .082809   2.70000   .000000  68/08/21 76/10/12
00955  SILICA    DISOLVED    MG/L                 66  26.7424   84.9651   9.21765   .344683   1.13461   45.0000   .000000  68/08/21 76/10/12
01000 ARSENIC    AS.DISS     UG/L                  4  7.25000   21.5833   4.64579   .640798   2.32289   12.0000   1.00000  74/12/13 76/10/12
01005  BARIUM    BA.DISS     UG/L                  4  50.0000   3333.33   57.7350   1.15470   28.8675   100.000   .000000  74/12/13 76/10/12
01020  BORON      B.DISS     UG/L                 66  56.0605   6891.93   83.0177   1.48086   10.2188   670.000   .000000  68/08/21 76/10/12
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STOCK FORM NO 61411

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                                                                       HUDSON RIVER AT GREEN ISLAND NY
                                                                       36001 NEW YORK
                                                                                          013292

/TYPA/AMBNT/STREAM                                                     112WRD             04001004
                                                                        0000  CLASS 00

PARAMETER                                      NUMBER    MEAN   VARIANCE  STAN DEV  COEF VAR  STAND ER  MAXIMUM   MINIMUM   BEG DATE END DATE
00005 VSAMPLOC      DEPTH     % OF TOT            9   99.9998   .015625   .125000   .001250   .041667   99.9998   99.9998  75/08/14 75/08/14
00008   LAB        IDENT.     NUMBER             13   1611.76    960547   980.075   .608076   271.824   2985.99   61.9999  71/01/20 73/09/18
00009 XSAMPLOC     FT FROM    LF  BANK           34   336.762   22229.3   149.095   .442730   25.5696   589.999   59.9999  75/08/14 75/09/08
00010  WATER        TEMP        CENT            149   13.3033   83.2334   9.12323   .685786   .747404   25.0000   .000000  65/11/05 76/09/24
00020   AIR         TEMP        CENT             91   12.3722   102.999   10.1488   .820298   1.06389   30.0000-.799E+01  68/01/28 76/09/24
00027  COLLECT     AGENCY       CODE              1   1028.00                                         1028.00   1028.00  73/02/21 73/02/21
00028  ANALYZE     AGENCY       CODE              1   1028.00                                         1028.00   1028.00  73/02/21 73/02/21
00060  STREAM       FLOW        CFS             177   10411.6 .110E+09   10491.6   1.00769   788.600   60700.0   15.5000  63/06/27 75/09/08
00061  STREAM       FLOW,     INST-CFS           25   15397.9 .138E+09   11779.4   .765000   2355.88   59399.9   3279.99  72/10/26 75/11/05
00065, STREAM       STAGE       FEET             75   17.1135   2.87854   1.69662   .099140   .195909   20.8000   7.00000  68/01/28 74/09/05
00070   TURB        JKSN        JTU              25   7.84000   23.0567   4.80174   .612466   .960347   20.0000  1.000000  64/09/10 76/09/24
00075   TURB        HLGE      PPM SIO2           25   .943994   .781738   .884159   .936615   .176832   3.00000   .000000  63/06/27 64/09/30
00080  COLOR       PT-CO       UNITS            100   23.9399   118.500   10.8858   .454712   1.08858   85.0000   5.00000  63/06/27 75/05/06
00095 CNDUCTVY     AT 25C     MICROMHO          230   192.555   1722.50   41.5030   .215539   2.73663   387.000   101.000  63/06/27 76/09/24
00300    DO                     MG/L             58   10.1758   7.30715   2.70317   .265648   .354944   15.0000   5.10000  71/10/21 76/09/24
00301    DO         SATUR     PERCENT            46   94.6607   88.1764   9.39023   .099199   1.38451   112.000   76.9999  72/10/26 76/09/24
00335   COD       LOWLEVEL      MG/L             73   14.3697   30.3217   5.50651   .383203   .644488   38.0000   5.00000  69/04/23 75/05/06
00400    PH                      SU             204   7.20432   .193119   .439453   .060998   .030768   8.20000   4.20000  63/06/27 76/09/24
00405   CO2                     MG/L             47   11.9403   2753.32   52.4721   4.39452   7.65384   363.000   .700000  72/05/23 76/09/24
00410  T ALK        CACO3       MG/L            135   48.6074   125.287   11.1932   .230277   .963354   80.0000   21.0000  63/11/28 76/09/24
00440 HCO3 ION      HCO3        MG/L            204   58.4348   182.813   13.5208   .231383   .946648   97.9999  .499E-06  63/06/27 76/09/24
00445 CO3 ION        CO3        MG/L            163 .171E-06 .567E-13  .238E-06   1.38657  .186E-07  .499E-06   .000000  64/10/06 76/09/24
00500 RESIDUE       TOTAL       MG/L             51   121.372   769.536   27.7405   .228558   3.88445   207.000   74.9999  71/01/20 75/05/06
00505 RESIDUE      TOT VOL      MG/L             28   17.3928   90.2491   9.49995   .546201   1.79532   53.0000   5.00000  68/03/26 71/04/26
00510 RESIDUE      TOT FIX      MG/L             53   92.6222   633.209   25.1636   .271681   3.45649   173.000   48.9999  68/03/26 75/05/06
00515 RESIDUE     DISS-105    C MG/L             47   114.574   1150.53   33.9195   .296048   4.94766   230.000   .000000  68/10/25 76/09/24
00525 RESIDUE      FIX FLT      MG/L             19   14.2631   425.427   20.6259   1.44610   4.73190   95.0000   .000000  71/02/26 72/09/21
00530 RESIDUE     TOT NFLT      MG/L             88   14.2454   250.428   15.8249   1.11088   1.68694   108.000   .000000  68/10/25 76/09/24
00540 RESIDUE     FIX NFLT      MG/L             32   8.01874   72.4627   8.51250   1.06158   1.50481   41.9999   .000000  72/10/26 75/05/06
00572 BIOMASS     PERPHYTN    G/SQ M              5   1.41520   5.32214   2.30698   1.63014   1.03171   5.53000   .200000  75/11/24 76/09/20
00573 BIOMASS     PERPHYTN    DW G/M2             5   1.61420   5.64055   2.37498   1.47131   1.06212   5.84000   .200000  75/11/24 76/09/20
00600 TOTAL N         N         MG/L             48   1.15802   .095268   .308655   .266538   .044550   1.82900   .480000  70/10/22 76/09/24
00605  ORG N          N         MG/L             81   .414872   .293574   .541825   1.30601   .060203   4.80000   .040000  68/07/26 75/05/06
00608  NH3-N        DISS        MG/L             27   .215592   .024498   .156520   .726000   .030122   .649999   .010000  71/07/20 73/09/18
00610  NH3-N        TOTAL       MG/L             20   .199000   .011367   .106618   .535771   .023841   .380000   .000000  73/10/25 75/05/06
00613  NO2-N        DISS        MG/L             27   .033481   .001570   .039623   1.18345   .007626   .130000   .001000  71/07/20 73/09/18
00615  NO2-N        TOTAL       MG/L             20   .021950   .001218   .034902   1.59007   .007804   .160000   .000000  73/10/25 75/05/06
00618  NO3-N        DISS        MG/L             28   .616428   .021543   .146775   .238106   .027738   .919999   .390000  71/07/20 73/09/18
00620  NO3-N        TOTAL       MG/L             20   .541500   .018950   .137660   .254220   .030782   .880000   .320000  73/10/25 75/05/06
00625 TOT KJEL        N         MG/L             36   .469166   .021443   .146433   .312113   .024406   .750001   .190000  73/02/21 76/09/24
00630 NO2&NO3      N-TOTAL      MG/L             32   .527812   .017986   .134110   .254087   .023708   .889999   .320000  73/10/25 76/09/24
00631 NO2&NO3      N-DISS       MG/L              5   .701999   .041720   .204256   .290963   .091346   .919999   .400000  73/05/22 73/09/18
00650  T PO4         PO4        MG/L             10   .226000   .023982   .154862   .685232   .048972   .640000   .110000  66/04/20 72/09/21
00660 ORTHOPO4       PO4        MG/L             18   .075555   .002591   .050900   .673684   .011997   .210000   .020000  72/10/26 74/03/22
00665 PHOS-TOT                 MG/L P            68   .062661   .001178   .034320   .547709   .004162   .210000   .014000  70/10/22 76/09/24
00671 PHOS-DIS      ORTHO      MG/L P            24   .025667   .000236   .015364   .598604   .003136   .068000   .006000  72/04/19 74/03/22
00680 T ORG C         C         MG/L             16   5.60000   9.52799   3.08675   .551205   .771686   15.0000   3.00000  74/08/08 76/08/26
00720 CYANIDE      CN-TOT       MG/L              1   .000000                                         .000000   .000000  73/02/21 73/02/21
00900 TOT HARD      CACO3       MG/L            190   70.2157   207.525   14.4057   .205164   1.04510   116.000   36.0000  63/06/27 76/09/24
00902 NC HARD       CACO3       MG/L            190   27.2838   586.310   24.2138   .887481   1.75666   127.000   9.00000  63/06/27 76/09/24
00915 CALCIUM      CA-DISS      MG/L            180   21.2388   19.7521   4.44433   .209255   .331261   34.0000   11.0000  63/06/27 76/09/24
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STOCK FORM NO. 61411

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STORET  DATE 77/01/28

                                                               01603000
                                                               39 37 16.0 078 46 24.0  2
                                                               NORTH BRANCH POTOMAC RIVER NEAR
                                                               24001 MARYLAND
                                                                                        021491
/TYPA/AMBNT/STREAM
                                                               112WRD              0400100+
                                                                0000  CLASS 00

PARAMETER
                                          NUMBER    MEAN   VARIANCE  STAN DEV  COEF VAR  STAND ER  MAXIMUM   MINIMUM  BEG DATE END DATE
00008    LAB       IDENT.     NUMBE-          12  2935644  .103E+15  .101E+08  3.46107   2933111  .351E+08  639.999  72/12/12 74/01/23
00010   WATER       TEMP        CENT         183  13.6565  78.9690   8.88645   .650712   .656905  32.2200   .000000  60/09/29 76/11/01
00020    AIR        TEMP        CENT          20  14.6500  96.9496   9.84630   .672104   2.20170  27.0000   .500000  74/02/28 76/09/01
00060   STREAM      FLOW        CFS          157  2338.54  .150E+08  3876.66   1.65772   309.391  21000.0   111.000  63/05/16 72/09/28
00061   STREAM      FLOW.     INST-CFS        78  2746.85  .134E+08  3665.86   1.33457   415.076  18400.0   152.000  71/11/30 76/11/01
00065   STREAM      STAGE       FEET          27  3.83888  4.40740   2.09938   .546874   .404026  12.4500   2.20000  73/04/27 76/09/01
00070    TURB       JKSN        JTU            9  37.8888  2329.86   48.2686   1.27396   16.0895  160.000   2.00000  69/10/02 73/12/05
00080   COLOR       PT-CO      UNITS         120  13.7249  591.443   24.3196   1.77193   2.22007  180.000   .000000  60/09/29 76/11/01
00085   ODOR      THRSH NO   RM. TEM-          4  17.2500  342.250   18.5000   1.07246   9.25000  45.0000   8.00000  61/04/18 71/09/30
00095 CNDUCTVY     AT 25C    MICROMH         213  431.971  62453.4   249.907   .578527   17.1233  1090.00   110.000  06/09/20 76/11/01
00300     DO                   MG/L           60  9.40492  10.7117   3.27288   .347996   .422527  13.9000   1.50001  60/09/29 74/01/23
00301     DO       SATUR     PERCENT           2  58.0000  .000000   .000000             .000000  58.0000   58.0000  60/09/29 61/04/18
00310    BOD       5 DAY       MG/L            9  3.73332  15.4926   3.93606   1.05430   1.31202  14.0000   1.10000  69/10/02 73/12/05
00335    COD      LOWLEVEL     MG/L            3  18.6666  212.334   14.5717   .780627   8.41296  35.0000   6.99999  73/03/13 73/12/05
00400     PH                    SU           185  6.81936  .311078   .557743   .081788   .041006  7.80000   4.60000  60/09/29 76/11/01
00405    CO2                   MG/L           92  7.57275  96.8061   9.83901   1.29926   1.02579  71.0000   .499E-06 63/05/16 76/11/01
00410   T ALK      CACO3       MG/L          166  26.7529  352.446   18.7735   .701738   1.45711  84.0000   .000000  06/09/20 76/11/01
00435 T ACDITY     CACO3       MG/L            4  17.2500  570.222   23.8793   1.38431   11.9397  52.9999   3.40000  73/09/14 73/12/05
00440 HCO3 ION      HCO3       MG/L          179  36.2623  704.150   26.5358   .731774   1.98338  144.000   .499E-06 06/09/20 76/11/01
00445 CO3 ION       CO3        MG/L          148  .162162  1.61924   1.27249   7.84704   .104598  12.0000   .000000  06/09/20 76/11/01
00515 RESIDUE    DISS-105    C MG/L            2  590.000  1800.00   42.4264   .071909   30.0000  620.000   560.000  72/09/28 73/09/14
00530 RESIDUE    TOT NFLT      MG/L            8  69.9999  18640.2   136.529   1.95042   48.2703  406.999   5.00000  69/10/02 73/09/14
00608   NH3-N       DISS       MG/L            3  .543333  .003634   .060283   .110950   .034804  .600000   .479999  72/07/19 73/09/14
00610   NH3-N      TOTAL       MG/L            1  .400000                                         .400000   .400000  73/12/05 73/12/05
00613   NO2-N       DISS       MG/L            2  .006500  .000024   .004950   .761500   .003500  .010000   .003000  73/06/06 73/09/14
00615   NO2-N      TOTAL       MG/L            6  .007500  .000037   .006058   .807739   .002473  .017000   .000000  73/10/17 74/04/01
00618   NO3-N       DISS       MG/L           25  .517999  .033184   .182163   .351667   .036433  .799999   .140000  71/10/27 73/09/14
00620   NO3-N      TOTAL       MG/L            7  .691428  .015981   .126417   .182835   .047781  .800000   .470000  72/06/23 74/04/01
00630 NO2&NO3     N-TOTAL      MG/L           33  .612725  .041299   .203220   .331667   .035376  1.10000   .220000  73/10/17 76/11/01
00631 NO2&NO3     N-DISS       MG/L            2  .599999  .020001   .141425   .235709   .100003  .699999   .500000  73/06/06 73/09/14
00650   T PO4       PO4        MG/L           16  .151875  .063216   .251428   1.65550   .062857  .900000   .000000  65/05/18 72/09/28
00665 PHOS-TOT               MG/L P           36  .088805  .012815   .113202   1.27472   .018867  .659999   .006000  69/10/02 76/11/01
00720 CYANIDE      CN-TOT      MG/L           10  .006000  .000049   .006992   1.16534   .002211  .020000   .000000  61/04/18 73/12/05
00900 TOT HARD     CACO3       MG/L          152  164.755  7662.27   87.5344   .531300   7.09998  385.000   43.0000  60/09/29 76/11/01
00902 NC HARD      CACO3       MG/L          152  134.466  5504.62   74.1931   .551763   6.01786  313.000   22.0000  60/09/29 76/11/01
00915 CALCIUM     CA.DISS      MG/L          175  45.4500  755.489   27.4862   .604756   2.07776  127.000   12.0000  06/09/20 76/11/01
00925 MGNSIUM     MG.DISS      MG/L          173  9.22072  33.9816   5.82937   .632204   .443199  45.0000   2.50000  06/09/20 76/11/01
00930  SODIUM     NA.DISS      MG/L          149  24.8811  507.979   22.5384   .905845   1.84642  102.000   2.50000  60/09/29 76/11/01
00931  SODIUM    ADSRTION     RATIO          136  .710288  .201821   .449245   .632483   .038522  2.70000   .200000  60/09/29 76/11/01
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STOCK FORM NO. 61411

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STORET  DATE 77/01/28

                                                         14191000
                                                         44 56 40.0 123 02 30.0  2
                                                         WILLAMETTE RIVER AT SALEM.OREG.
                                                         41347 OREGON
                                                                                130991
/TYPA/AMBNT/STREAM
                                                         112WRD            0400100+
                                                          0000  CLASS 00

PARAMETER                                     NUMBER     MEAN  VARIANCE  STAN DEV  COEF VAR  STAND ER   MAXIMUM   MINIMUM  BEG DATE  END DATE
00008   LAB       IDENT.     NUMBE-                2  979.500    261365   511.239   .521938   361.500   1341.00   618.000  73/09/19  74/01/29
00010  WATER       TEMP       CENT                13  12.6000   31.2750   5.59240   .443842   1.55105   20.0000   4.70000  70/06/15  76/07/14
00060  STREAM      FLOW       CFS                262  28810.7  .107E+10   32743.7   1.13651   2022.91    285000   625.000  59/10/20  73/09/19
00061  STREAM      FLOW,    INST-CFS              17  28016.5  .442E+09   21032.1   .750707   5101.04   71799.8   6981.00  73/06/26  76/06/03
00080  COLOR      PT-CO      UNITS                 8  10.0000   78.5714   8.86405   .886405   3.13391   20.0000  .499E-06  67/10/23  69/03/01
00095 CNDUCTVY   AT 25C    MICROM-3              278  61.9792   178.101   13.3455   .215321   .800407   141.000   7.10000  59/10/20  76/07/14
00400    PH                   SU                 271  6.89990   .228602   .478124   .069294   .029044   9.80000   4.80000  59/10/20  76/06/03
00405   CO2                  MG/L                 17  2.92352   8.60566   2.93354   1.00343   .711489   9.60000   .200000  72/10/18  76/06/03
00410  T ALK      CACO3      MG/L                225  20.2933   21.5831   4.64577   .228931   .309718   42.0000   7.00000  60/10/28  76/07/14
00440 HCO3 ION    HCO3       MG/L                277  24.4184   33.4678   5.78514   .236917   .347595   51.0000  .499E-06  59/10/20  76/07/14
00445 CO3 ION      CO3       MG/L                215  .097675   .873598   .934664   9.56916   .063744   11.0000   .000000  60/10/28  76/06/03
00515 RESIDUE   DISS-105   C MG/L                 17  46.4117   40.8887   6.39443   .137776   1.55088   60.0000   39.0000  70/11/11  74/01/29
00530 RESIDUE   TOT NFLT     MG/L                 17  21.4706   344.139   18.5510   .864019   4.49927   73.0000   7.00000  70/11/11  74/01/29
00600 TOTAL N       N        MG/L                  1  .440000                                          .440000   .440000  72/03/22  72/03/22
00625 TOT KJEL      N        MG/L                  2  .345000   .011250   .106066   .307439   .075000   .420000   .270000  71/04/28  72/03/22
00631 NO2&NO3    N-DISS      MG/L                 35  .550856   .161427   .401780   .729375   .067913   1.50000   .070000  70/12/17  76/07/14
00665 PHOS-TOT               MG/L P               21  .069047   .002709   .052049   .753810   .011358   .270000   .010000  70/12/17  76/07/14
00900 TOT HARD    CACO3      MG/L                278  20.1867   10.1742   3.18970   .158010   .191306   38.0000   12.0000  59/10/20  76/07/14
00902 NC HARD     CACO3      MG/L                278  1.30935   5.98338   2.44610   1.86818   .146707   15.0000   .000000  59/10/20  76/07/14
00915 CALCIUM    CA.DISS     MG/L                179  5.41226   .588596   .767200   .141752   .058842   8.80000   3.80000  59/10/20  76/07/14
00925 MGNSIUM    MG.DISS     MG/L                169  1.76211   .087747   .296221   .168105   .022786   2.60000   .700000  59/10/20  76/07/14
00930  SODIUM    NA.DISS     MG/L                278  3.77295   .826184   .908947   .240912   .054515   11.0000   2.10000  59/10/20  76/07/14
00931  SODIUM   ADSBTION     RATIO               265  .387917   .172355   .415157   1.07022   .025503   7.00000   .200000  59/10/20  76/07/14
00932  PERCENT    SODIUM     %                   228  28.2149   9.92373   3.15020   .111650   .208627   43.0000   19.0000  60/10/28  76/07/14
00935 PTSSIUM     K.DISS     MG/L                 96  .884440   .952795   .976112   1.10365   .102891   8.80000   .200000  59/10/20  76/07/14
00940 CHLORIDE      CL       MG/L                 88  3.16363   2.23294   1.49430   .472338   .159293   7.90000   .000000  59/10/20  76/07/14
00945 SULFATE    SO4-TOT     MG/L                 81  3.75801   2.57578   1.60492   .427067   .178325   8.00000   .200000  59/10/20  76/07/14
00950 FLUORIDE    F.DISS     MG/L                 86  .093023   .007009   .083723   .900020   .009028   .400000   .000000  59/10/20  76/07/14
00955  SILICA    DISOLVED    MG/L                 84  14.3583   5.22581   2.28600   .159211   .249423   17.0000   4.30000  59/10/20  76/07/14
01020  BORON      B.DISS     UG/L                 37  9.19023   229.859   15.1611   1.64970   2.49247   70.0000   .000000  59/10/20  68/10/04
01046   IRON     FE.DISS     UG/L                 36  101.944   6210.40   78.8061   .773030   13.1343   340.000   10.0000  70/12/17  76/07/14
01056 MANGNESE   MN.DISS     UG/L                  1  7.00000                                          7.00000   7.00000  72/06/08  72/06/08
01515 ALPHA-D    AS U-NAT    PC/L                 14  .150000   .005769   .075956   .506374   .020300   .300000   .100000  70/11/11  72/10/18
01516 ALPHA-S    AS U-NAT    PC/L                 14  .235714   .048626   .220514   .935515   .058935   .800000   .100000  70/11/11  72/10/18
03515  BETA-D    AS CS137    PC/L                 17  1.23529   .084929   .291427   .235917   .070681   1.70000   .700000  70/11/11  74/01/29
03516  BETA-S    AS CS137    PC/L                 17  .864705   .373673   .611288   .706932   .148259   2.60000   .400000  70/11/11  74/01/29
09503  RA-226    DISOLVED    PC/L                  8  .030000   .000086   .009258   .308608   .003273   .040000   .020000  69/10/09  70/09/30
09510 RA-226-D   PLCHT CT    PC/L                  1  .100000                                          .100000   .100000  72/10/18  72/10/18
09511 RA-226-D   RADON MT    PC/L                 16  .027500   .000233   .015275   .555463   .003819   .070000   .010000  70/11/11  74/01/29
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STOCK FORM NO. 61411

data from sampling stations of several years of record. Significant between-year differences can be demonstrated for essentially all of the nutrient parameters, and the comparisons are on file at CERL.

One example of difference is shown in the following comparison of U.S.G.S. data for water years 1973 and 1974 at the same station on the Big Sioux River in eastern South Dakota. The nutrient parameters compared are indicated by the arrows. While the means of five of the six parameters do not differ significantly, the null hypotheses of no difference between the means of total phosphorus for the two years (underlined) is rejected at the 0.05 probability level (t = 2.295 with 36 d. f.).

In our assessment of the reliability of the NES tributary data, for the most part we found it necessary to utilize STORET again because of a scarcity of published stream data. After some effort we were able to retrieve comparable data obtained by other agencies (primarily U.S.G.S.) at or near nine of the 4,000+ NES sampling stations. The data were selectively retrieved to provide periods of record that are comparable to the NES sampling times.

The evaluations are shown on the following pages as reproductions of the data retrievals, and the parameters compared are indicated by the double-pointed arrows. On the first page, the agency codes are circled in the headings (112WRD is the code for the Water Resources Division of U.S.G.S., 11EPALES is the NES code, and 21CAL-1 is the code for the California Department of Water Resources).

In only five of the 32 parameter comparisons shown were the means of the NES data and other agency data significantly different at the 0.05 level as indicated by Student's t-tests. The five are indicated by the underlined parameter names (e.g., "00610 NH3-N" in the Hackensack River data). It will be noted that none of the means of the phosphorus species differed significantly and that only two of the five differing comparisons involve a parameter that would affect calculated nutrient loads ("00625 TOT KJEL").

The NES stream data also were compared to data reported by the Georgia Department of Natural Resources (Anonymous, 1974), the Illinois Environmental Protection Agency (Anonymous, 1972), and the Wisconsin Department of Natural Resources (Anonymous, 1975).

In 1973, the Georgia DNR collected from 4 to 14 samples at seven comparable sites on five streams from which 13 or 14 samples were collected by the NES during the period of March 1973 through February, 1974. There is excellent agreement between DNR and NES total phosphorus data (the mean of all DNR TP data is 228 μg/l and the mean of all NES data is 227 μg/l; the coefficient of rank correlation is 1.00, n = 7).

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STORET  DATE 77/03/16
                                                                  06481000
                                                                  43 47 25.0 096 44 42.0  2
                                                                  BIG SIOUX R NR DELL RAPIDS,S.DAK
                                                                  46099 SOUTH DAKOTA
                                                                                             090791

/TYPA/AMBNT/STREAM                                                112WRD             04001004
                                                                   0000  CLASS 00


PARAMETER                                          NUMBER     MEAN   VARIANCE  STAN DEV  COEF VAR  STAND ER  MAXIMUM   MINIMUM   BEG DATE END DATE
00010  WATER        TEMP         CENT                  24  10.8166    102.030   10.1010   .933836   2.06185   26.5000   .000000 72/10/26 73/09/27
00020   AIR         TEMP         CENT                  12  11.3583    121.502   11.0228   .970461   3.18201   30.0000-.199E+01 72/10/26 73/09/27
00060  STREAM       FLOW         CFS                   35  246.683     125520   354.288   1.43620   59.8856   1770.00   18.0000 72/10/26 73/09/30
00095 CNDUCTVY     AT 25C       MICROMHC               35  860.484    12194.3   110.428   .128332   18.6657   1200.00   585.000 72/10/26 73/09/30
00300    DO                      MG/L                  12  10.7250    8.58212   2.92953   .273150   .845681   15.8000   5.00000 72/10/26 73/09/27
00310   BOD        5 DAY         MG/L                  12  3.89165    1.16270   1.07829   .277077   .311275   6.59999   2.50000 72/10/26 73/09/27
00400    PH                       SU                   35  8.02855    .141752   .376500   .046895   .063640   9.09999   7.40000 72/10/26 73/09/30
00405   CO2                      MG/L                  23  6.54347    15.0453   3.87882   .592778   .808791   19.0000   2.90000 72/10/26 73/09/30
00410  T ALK       CACO3         MG/L                  23  217.617    1853.23   43.0491   .197820   8.97636   323.000   146.000 72/10/26 73/09/30
00440 HCO3 ION      HCO3         MG/L                  23  265.260    2759.18   52.5279   .198024   10.9528   394.000   178.000 72/10/26 73/09/30
00445 CO3 ION       CO3          MG/L                  23  .000000    .000000   .000000             .000000   .000000   .000000 72/10/26 73/09/30
00600 TOTAL N        N           MG/L <------->        12  2.59166    .891761   .944331   .364372   .272605   4.30000   1.40000 72/10/26 73/09/27
00605  ORG N         N           MG/L                  12  1.55500    .315861   .562015   .361424   .162240   2.70000   .780000 72/10/26 73/09/27
00608  NH3-N        DISS         MG/L                   4  .452500    .167292   .409013   .903897   .204507   1.00000   .080000 72/10/26 73/01/30
00610  NH3-N       TOTAL         MG/L <------->        10  .382000    .109840   .331421   .867595   .104804   1.00000   .050000 72/12/20 73/09/27
00613  NO2-N        DISS         MG/L                  12  .019167    .000572   .023916   1.24779   .006904   .080000   .000000 72/10/26 73/09/27
00618  NO3-N        DISS         MG/L                  12  .599167    .564863   .751574   1.25436   .216961   2.10000   .000000 72/10/26 73/09/27
00625 TOT KJEL       N           MG/L <------->        12  1.90000    .276371   .525710   .276690   .151759   2.90000   1.20000 72/10/26 73/09/27
00630 NO2&NO3     N-TOTAL        MG/L <------->         8  .487500    .531050   .728732   1.49483   .257646   2.10000   .000000 73/02/21 73/09/27
00631 NO2&NO3      N-DISS        MG/L                  23  1.03956    .937209   .968096   .931255   .201862   3.40000   .000000 72/10/26 73/09/30
00660 ORTHOPO4      PO4          MG/L                  22  .451818    .151177   .388815   .860557   .082896   1.40000   .000000 72/10/26 73/09/30
00665 PHOS-TOT                   MG/L P <------->      23  .258261    .017688   .132995   .514963   .027731   .530000   .100000 72/10/26 73/09/30
00666 PHOS-DIS                   MG/L P                14  .242143    .021203   .145612   .601348   .038916   .520000   .020000 72/10/26 73/09/30
00671 PHOS-DIS     ORTHO         MG/L P <------->      22  .147727    .015980   .126414   .855723   .026951   .440000   .000000 72/10/26 73/09/30
00900 TOT HARD     CACO3         MG/L                  23  386.956    2995.18   54.7283   .141433   11.4116   510.000   270.000 72/10/26 73/09/30



00600 TOTAL N        N           MG/L <------->        14  2.42142    .583367   .763785   .315428   .204130   4.20000   1.60000 73/11/08 74/09/16
00605  ORG N         N           MG/L                  14  1.59428    .369384   .607769   .381218   .162433   2.90000   .400000 73/11/08 74/09/16
00610  NH3-N       TOTAL         MG/L <------->        14  .454286    .235457   .485239   1.06814   .129686   1.50000   .040000 73/11/08 74/09/16
00613  NO2-N        DISS         MG/L                   3  .033333    .000533   .023094   .692820   .013333   .060000   .020000 73/11/08 74/01/10
00618  NO3-N        DISS         MG/L                   3  .873334    1.36003   1.16621   1.33535   .673309   2.20000   .010000 73/11/08 74/01/10
00625 TOT KJEL       N           MG/L <------->        14  2.04286    .113414   .336770   .164852   .090005   3.00000   1.60000 73/11/08 74/09/16
00630 NO2&NO3     N-TOTAL        MG/L <------->        15  .376000    .362783   .602315   1.60190   .155517   2.30000   .000000 73/11/08 74/09/16
00631 NO2&NO3      N-DISS        MG/L                   9  .390000    .566525   .752678   1.92994   .250893   2.30000   .000000 73/11/08 74/09/05
00660 ORTHOPO4      PO4          MG/L                   9  .365555    .163028   .403767   1.10453   .134589   1.20000   .030000 73/11/08 74/09/05
00665 PHOS-TOT                   MG/L P <------->      15  .360000    .018086   .134483   .373565   .034723   .550000   .130000 73/11/08 74/09/16
00666 PHOS-DIS                   MG/L P                 6  .138333    .020057   .141622   1.02377   .057817   .410000   .020000 74/03/06 74/09/05
00671 PHOS-DIS     ORTHO         MG/L P <------->       9  .120000    .017900   .133791   1.11493   .044597   .400000   .010000 73/11/08 74/09/05
00680 T ORG C        C           MG/L                  12  11.9750    11.8639   3.44440   .287633   .994313   19.0000   8.10000 74/03/06 74/09/16
00900 TOT HARD     CACO3         MG/L                   9  388.333    17825.1   133.511   .343805   44.5036   620.000   95.0000 73/11/08 74/09/05
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STORET  DATE 77/03/16
                                                          06409000
                                                          44 00 49.0 103 49 48.0  2
                                                          CASTLE CR ABV DEERFIELD RES, NR
                                                          46103 SOUTH DAKOTA
                                                                                    090491
/TYPA/AMBNT/STREAM                                        112WRD               04001004
                                                           0000  CLASS 00

PARAMETER                                     NUMBER    MEAN   VARIANCE STAN DEV COEF VAR STAND ER MAXIMUM  MINIMUM  BEG DATE END DATE
00008   LAB       IDENT.      NUMBER              1   751146                                          751146   751146 74/10/15 74/10/15
00010  WATER       TEMP        CENT              13  5.11537  35.5063  5.95872  1.16486  1.65265  18.5000  .000000 74/10/15 75/09/10
00020   AIR        TEMP        CENT               1  5.00000                                      5.00000  5.00000 74/11/25 74/11/25
00061  STREAM      FLOW.     INST-CFS            13  10.7692  17.7773  4.21631  .391515  1.16939  22.0000  6.49999 74/10/15 75/09/10
00095 CNDUCTVY    AT 25C     MICROMHO            12  501.833  3140.27  56.0381  .111667  16.1768  610.000  395.000 74/10/15 75/09/10
00300    DO                    MG/L               6  10.9500  1.23511  1.11135  .101494  .453708  12.2000  9.39999 74/10/15 75/06/10
00400    PH                     SU               12  8.44999  .155495  .394329  .046666  .113833  9.00000  7.70000 74/10/15 75/09/10
00405   CO2                    MG/L              11  2.51817  8.32167  2.88473  1.14556  .869779  10.0000  .400000 74/10/15 75/09/10
00410  T ALK       CACO3       MG/L              11  250.818  334.575  18.2914  .072927  5.51506  270.000  214.000 74/10/15 75/09/10
00440 HCO3 ION      HCO3       MG/L              11  303.545  477.762  21.8578  .072008  6.59037  329.000  261.000 74/10/15 75/09/10
00445 CO3 ION       CO3        MG/L               6  2.00000  19.6000  4.42719  2.21359  1.80739  11.0000  .000000 75/03/18 75/09/10
00515 RESIDUE     DISS-105   C MG/L               1  300.000                                      300.000  300.000 74/10/15 74/10/15
00530 RESIDUE     TOT NFLT     MG/L               1  3.00000                                      3.00000  3.00000 74/10/15 74/10/15
00630 NO2&NO3     N-TOTAL      MG/L   ⇄          11  .106363  .003666  .060543  .569212  .018255  .190000  .020000 74/10/15 75/09/10
00665 PHOS-TOT                MG/L P  ⇄          11  .030000  .001120  .033466  1.11555  .010090  .110000  .000000 74/10/15 75/09/10
00720 CYANIDE      CN-TOT      MG/L               2  .000000  .000000  .000000           .000000  .000000  .000000 74/10/15 75/07/08

STORET  DATE 77/03/16
                                                          4610A2
                                                          44 00 49.0 103 49 48.0  4
                                                          CASTLE CREEK
                                                          46    7.5 DEERFIELD
                                                          T/DEERFIELD LAKE            090491
/TYPA/AMBNT/STREAM                                        SEC RD BRDG 2.5 MI SW OF DEERFIELD DAM
                                                          11EPALES             04001004
                                                           0000  CLASS 00

PARAMETER                                     NUMBER    MEAN   VARIANCE STAN DEV COEF VAR STAND ER MAXIMUM  MINIMUM  BEG DATE END DATE
00610  NH3-N       TOTAL       MG/L              13  .017769  .000106  .010289  .579021  .002854  .040000  .005000 74/10/12 75/09/21
00615  NO2-N       TOTAL       MG/L               2  .004000-.145E-10  .000000           .000000  .004000  .004000 74/10/12 74/11/19
00620  NO3-N       TOTAL       MG/L               2  .072000  .002048  .045255  .628540  .032000  .104000  .040000 74/10/12 74/11/19
00625 TOT KJFL       N         MG/L              13  .515384  .088494  .297479  .577198  .082506  1.30000  .100000 74/10/12 75/09/21
00630 NO2&NO3     N-TOTAL      MG/L   ⇄          13  .099461  .004042  .063575  .639196  .017633  .184000  .010000 74/10/12 75/09/21
00665 PHOS-TOT                MG/L P  ⇄          13  .030385  .000269  .016389  .539376  .004545  .060000  .010000 74/10/12 75/09/21
00671 PHOS-DIS     ORTHO      MG/L P             13  .012231  .000038  .006126  .500855  .001699  .025000  .005000 74/10/12 75/09/21
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STORET  DATE 77/03/21
                                                          03579100
                                                          35 17 08.0 086 06 20.0  2
                                                           ELK RIVER NEAR ESTILL SPRINGS.
                                                          47051 TENNESSEE
                                                                                 040692
/TYPA/AMBNT/STREAM
                                                          112WRD              04001004
                                                           0000  CLASS 00

PARAMETER                                      NUMBER   MEAN   VARIANCE STAN DEV COEF VAR STAND ER MAXIMUM  MINIMUM  BEG DATE END DATE
00010  WATER      TEMP      CENT                    6  12.9833  4.24184  2.05957  .158632  .840818  15.0000  10.5000 73/12/04 74/05/07
00061  STREAM     FLOW.     INST-CFS                7  721.141   857018  925.753  1.28373  349.902  2741.00  54.9999 73/10/26 74/05/07
00070   TURB      JKSN       JTU                    6  11.2166  59.9576  7.74323  .690333  3.16116  22.0000  4.29999 73/12/04 74/05/07
00080  COLOR      PT-CO     UNITS                   6  24.1666  354.164  18.8192  .778728  7.68292  59.9999  9.99999 73/12/04 74/05/07
00095 CNDUCTVY    AT 25C    MICROMHO                6  131.666  216.675  14.7199  .111797  6.00937  150.000  110.000 73/12/04 74/05/07
00300    DO                  MG/L                   6  10.0500  4.99106  2.23407  .222296  .912055  13.5000  7.09999 73/12/04 74/05/07
00335   COD     LOWLEVEL     MG/L                   4  5.74999  9.58336  3.09570  .538384  1.54785  9.99999  3.00000 74/02/13 74/05/07
00400    PH                   SU                    6  7.88332  .909814  .953842  .120995  .389404  8.99999  6.59999 73/12/04 74/05/07
00410  T ALK      CACO3      MG/L                   6  54.8332  53.7750  7.33314  .133735  2.99374  65.9999  45.9999 73/12/04 74/05/07
00530 RESIDUE    TOT NFLT    MG/L                   6  7.16665  20.9666  4.57893  .638922  1.86934  14.0000  4.00000 73/12/04 74/05/07
00605  ORG N        N        MG/L                   6  .171666  .008457  .091960  .535693  .037543  .330000  .090000 73/12/04 74/05/07
00610  NH3-N      TOTAL      MG/L   <------>        6  .043333  .000227  .015056  .347436  .006146  .060000  .020000 73/12/04 74/05/07
00630 NO2&NO3    N-TOTAL     MG/L   <------>        6  .491666  .019857  .140915  .286607  .057528  .589999  .220000 73/12/04 74/05/07
00650  T PO4       PO4       MG/L                   1  .140000                                      .140000  .140000 73/12/04 73/12/04
00665 PHOS-TOT               MG/L P <------>        5  .020000  .000050  .007071  .353559  .003162  .030000  .010000 74/01/29 74/05/07
00900 TOT HARD    CACO3      MG/L                   6  66.1665  18.9766  4.35621  .065837  1.77841  70.9999  60.9999 73/12/04 74/05/07

STORET  DATE 77/03/21
                                                          4728A1
                                                          35 17 57.0 086 05 47.0  4
                                                          ELK RIVER
                                                          47    7.5 CAPITOL HILL
                                                          O/WOODS RES                  040692
                                                          ELK RIVER DAM OR BANK JUST BELO DAM
/TYPA/AMBNT/STREAM
                                                          11EPALES             04001004
                                                           0000  CLASS 00

PARAMETER                                      NUMBER   MEAN   VARIANCE STAN DEV COEF VAR STAND ER MAXIMUM  MINIMUM  BEG DATE END DATE
00610  NH3-N      TOTAL      MG/L   <------>       12  .123750  .038305  .195717  1.58156  .056499  .730000  .020000 73/06/11 74/03/26
00615  NO2-N      TOTAL      MG/L                  12  .012667  .000399  .019970  1.57655  .005765  .074000  .002000 73/06/11 74/03/26
00620  NO3-N      TOTAL      MG/L                  12  .377416  .066539  .257952  .683466  .074464  .680000  .027000 73/06/11 74/03/26
00625 TOT KJFL      N        MG/L                  12  .707499  .221384  .470515  .665039  .135826  1.54000  .200000 73/06/11 74/03/26
00630 NO2&NO3    N-TOTAL     MG/L   <------>       12  .389833  .069185  .263031  .674727  .075930  .680000  .024000 73/06/11 74/03/26
00665 PHOS-TOT               MG/L P <------>       12  .033125  .000231  .015193  .458654  .004386  .070000  .017500 73/06/11 74/03/26
00671 PHOS-DIS    ORTHO      MG/L P                11  .014591  .000032  .005687  .389761  .001715  .023000  .005000 73/06/11 74/03/26
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STORET  DATE 77/03/28

                                                                  01378500
                                                                 40 56 52.0 074 01 34.0  2
                                                                 HACKENSACK R AT NEW MILFORD NJ
                                                                 34003 NEW JERSEY
                                                                                           013391
/TYPA/AMBNT/STREAM
                                                                 112WRD                04001004
                                                                  0000  CLASS 00

PARAMETER
                                               NUMBER    MEAN   VARIANCE STAN DEV COEF VAR STAND ER MAXIMUM  MINIMUM  BEG DATE END DATE
00008   LAB       IDENT.     NUMBER                 1  4599990
00010  WATER       TEMP       CENT                 12  16.5000  59.2199  7.69545  .466392  2.22148  4599990  4599990 74/02/12 74/02/12
00020   AIR        TEMP       CENT                  3  12.5000  100.750  10.0374  .802995  5.79510  26.0000  1.60000 73/07/11 74/07/10
00061  STREAM      FLOW.    INST-CFS                9  28.6666  687.249  26.2154  .914494  8.73848  19.5000  .999999 74/04/04 74/06/03
00095 CNDUCTVY    AT 25C    MICROMHO                9  321.888  381.859  19.5412  .060708  6.51374  94.9999  14.0000 73/07/11 74/07/10
00300    DO                   MG/L                  7  7.98856  12.0703  3.47423  .434901  1.31313  353.000  287.000 73/07/11 74/07/10
00310   BOD       5 DAY       MG/L                  9  2.62222  5.92444  2.43402  .928229  .811339  11.8000  1.32000 73/07/11 74/07/10
00400    PH                    SU                   8  7.57499  .290737  .539200  .071182  .190636  8.29999  .000000 73/07/11 74/07/10
00405   CO2                   MG/L                  1  33.0000                                     8.29999  6.59999 73/07/11 74/07/10
00410  T ALK      CACO3       MG/L                  1  67.0000                                     33.0000  33.0000 73/08/17 73/08/17
00430 CO3 ALK     CACO3       MG/L                  1  .000000                                     67.0000  67.0000 73/08/17 73/08/17
00440 HCO3 ION     HCO3       MG/L                  1  81.9999                                     .000000  .000000 73/08/17 73/08/17
00445 CO3 ION      CO3        MG/L                  1  .000000                                     81.9999  81.9999 73/08/17 73/08/17
00600 TOTAL N       N         MG/L                  4  1.59500  .124100  .352278  .220864  .176139  .000000  .000000 73/08/17 73/08/17
00605  ORG N        N         MG/L                  4  .325000  .006967  .083468  .256825  .041734  2.10000  1.28000 73/08/17 74/05/16
00610  NH3-N      TOTAL       MG/L   <---->         4  .289999  .032067  .179072  .617490  .089536  .420000  .220000 73/08/17 74/05/16
00615  NO2-N      TOTAL       MG/L   <---->         4  .023500  .000086  .009256  .393860  .004628  .549999  .150000 73/08/17 74/05/16
00620  NO3-N      TOTAL       MG/L   <---->         4  .955250  .194697  .441245  .461915  .220622  .030000  .010000 73/08/17 74/05/16
00625 TOT KJFL      N         MG/L   <---->         4  .614999  .052167  .228401  .371384  .114200  1.40000  .351000 73/08/17 74/05/16
00630 NO2&NO3    N-TOTAL      MG/L   <---->         3  1.16666  .043334  .208169  .178431  .120187  .899999  .370000 73/08/17 74/05/16
00660 ORTHOPO4     PO4        MG/L                  3  .062333  .000916  .030271  .485630  .017477  1.40000  .999999 73/11/27 74/05/16
00665 PHOS-TOT              MG/L P   <---->         4  .063000  .000876  .029597  .469800  .014799  .090000  .030000 73/08/17 74/02/12
00671 PHOS-DIS    ORTHO     MG/L P   <---->         2  .020000  .000200  .014142  .707107  .010000  .100000  .030000 73/08/17 74/05/ 6
00680 T ORG C       C         MG/L                  3  7.99999  76.0001  8.71780  1.08973  5.03322  .030000  .010000 73/11/27 74/02/12
00685 T. INORG      C         MG/L                  1  20.0000                                     18.0000  2.00000 73/08/17 74/05/16
                                                                                                   20.0000  20.0000 73/08/17 73/08/17

STORET  DATE 77/03/28

                                                                  3406A1
                                                                 40 57 15.0 074 01 46.0  4
                                                                 HACKENSACK RIVER
                                                                 34     7.5 HACKENSACK
                                                                 U/ORADELL RESERVOIR      013391
/TYPA/AMBNT/STREAM                                               ORADELL AVE BRDG 0.1 MI S OF DAM
                                                                 11EPALES              04001004
                                                                  0000  CLASS 00

PARAMETER
                                               NUMBER    MEAN   VARIANCE STAN DEV COEF VAR STAND ER MAXIMUM  MINIMUM  BEG DATE END DATE
00610  NH3-N      TOTAL       MG/L   <---->        15  .117666  .009374  .096819  .822825  .024999  .415000  .020000 73/07/21 74/07/21
00615  NO2-N      TOTAL       MG/L   <---->        15  .019467  .000095  .009738  .500263  .002514  .036000  .002000 73/07/21 74/07/21
00620  NO3-N      TOTAL       MG/L   <---->        15  1.02967  .251685  .501682  .487228  .129534  1.90000  .380000 73/07/21 74/07/21
00625 TOT KJFL      N         MG/L   <---->        14  .810000  .051785  .227563  .280942  .060819  1.40000  .500000 73/07/21 74/07/21
00630 NO2&NO3    N-TOTAL      MG/L   <---->        15  1.05427  .246863  .496853  .471279  .128287  1.90000  .410000 73/07/21 74/07/21
00665 PHOS-TOT              MG/L P   <---->        15  .050333  .000877  .029609  .588250  .007645  .125000  .005000 73/07/21 74/07/21
00671 PHOS-DIS    ORTHO     MG/L P   <---->        15  .012067  .000100  .010003  .829007  .002583  .032000  .005000 73/07/21 74/07/21
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STORET  DATE 77/03/21                                     F3159901
                                                          41 55 41.0 122 26 35.0  2
                                                          KLAMATH R BL IRON GATE DAM
                                                          06093 CALIFORNIA
                                                          KLAMATH RIVER
                                                          KLAMATH RIVER
                                                          21CAL-1   760521     04001004
/TYPA/AMBNT/STREAM                                         0000  CLASS 00

                                             NUMBER    MEAN   VARIANCE STAN DEV COEF VAR STAND ER MAXIMUM  MINIMUM  BEG DATE END DATE
PARAMETER
00010  WATER      TEMP      CENT                 12  11.6667  47.1970  6.87001  .588858  1.98320  22.0000  2.00000 74/11/07 75/10/15
00011  WATER      TEMP      FAHN                  1  49.0000                                      49.0000  49.0000 75/11/05 75/11/05
00027  COLLECT   AGENCY     CODE                 13  5050.00  .000000  .000000           .000000  5050.00  5050.00 74/11/07 75/11/05
00061  STREAM     FLOW.   INST-CFS               11  2887.27  2624161  1619.93  .561058  488.426  5900.00  990.000 74/11/07 75/09/18
00076   TURB    TRBIDMTR  HACH FTU               13  5.84615  32.1410  5.66931  .969750  1.57238  21.0000  1.00000 74/11/07 75/11/05
00094 CNDUCTVY  FIELD     MICROMHO               12  176.750  357.114  18.8974  .106916  5.45522  215.000  143.000 74/11/07 75/11/05
00095 CNDUCTVY   AT 25C   MICROMHO                3  190.000  67.0000  8.18535  .043081  4.72581  199.000  183.000 74/11/07 75/05/05
00300    DO                 MG/L                 13  10.0692  2.56396  1.60124  .159023  .444103  12.2000  7.20000 74/11/07 75/11/05
00400    PH                  SU                  13  7.69999  .168376  .410336  .053290  .113807  8.40000  7.20000 74/11/07 75/11/05
00403   LAB        PH        SU                   3  7.53333  .003456  .058789  .007804  .033942  7.60000  7.50000 74/11/07 75/05/05
00440 HCO3 ION    HCO3      MG/L                  3  87.3333  57.3457  7.57269  .086710  4.37210  96.0000  82.0000 74/11/07 75/05/05
00445 CO3 ION     CO3       MG/L                  3  .000000  .000000  .000000           .000000  .000000  .000000 74/11/07 75/05/05
00618  NO3-N      DISS      MG/L     ↔            3  .470000  .111701  .334217  .711100  .192960  .750000  .100000 74/11/07 75/05/05
00625 TOT KJFL     N        MG/L     ↔            2  .900000  .020001  .141426  .157140  .100003  1.00000  .800000 75/03/18 75/05/05
00665 PHOS-TOT             MG/L P    ↔            2  .180000  .012800  .113137  .628540  .080000  .260000  .100000 75/03/18 75/05/05
00671 PHOS-DIS   ORTHO     MG/L P    ↔            3  .123333  .003233  .056862  .461047  .032830  .170000  .060000 74/11/07 75/05/05
00900 TOT HARD   CACO3      MG/L                  3  60.0000  37.0000  6.08276  .101379  3.51188  67.0000  56.0000 74/11/07 75/05/05
00930  SODIUM   NA.DISS     MG/L                  3  16.3333  .333618  .577597  .035363  .333476  17.0000  16.0000 74/11/07 75/05/05
00940 CHLORIDE     CL       MG/L                  3  4.13333  .013321  .115416  .027923  .066636  4.20000  4.00000 74/11/07 75/05/05

STORET  DATE 77/03/21                                     0611A1
                                                          41 55 50.0 122 26 20.0  4
                                                          KLAMATH RIVER
                                                          06    15 COPCO
                                                          O/IRON GATE RESERVOIR    140191
                                                          BNK FRM COPCO RD .1 M BELO IRON GATE DAM
                                                          11EPALES              04001004
/TYPA/AMBNT/STREAM                                         0000  CLASS 00

                                             NUMBER    MEAN   VARIANCE STAN DEV COEF VAR STAND ER MAXIMUM  MINIMUM  BEG DATE END DATE
PARAMETER
00610  NH3-N     TOTAL      MG/L                 12  .208875  .024073  .155156  .742818  .044790  .480000  .015000 74/11/16 75/11/08
00620  NO3-N     TOTAL      MG/L     ↔            2  .272000  .073728  .271529  .998269  .192000  .464000  .080000 74/11/16 74/12/07
00625 TOT KJEL     N        MG/L     ↔           12  1.73333  1.90107  1.37879  .795458  .398023  5.90000  .800000 74/11/16 75/11/08
00630 NO2&NO3   N-TOTAL     MG/L                 12  .371666  .086903  .294793  .793166  .085099  .736000  .005000 74/11/16 75/11/08
00665 PHOS-TOT             MG/L P    ↔           12  .146667  .001624  .040302  .274786  .011634  .200000  .080000 74/11/16 75/11/08
00671 PHOS-DIS   ORTHO     MG/L P    ↔           12  .110000  .001772  .042091  .382643  .012151  .165000  .040000 74/11/16 75/11/08
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STORET  DATE 77/03/28
                                                                 12301933
                                                                48 24 23.0 115 18 57.0  2
                                                                KOOTENAI RIVER BL LIBBY DAM, NEA
                                                                30053 MONTANA
                                                                                              130191

/TYPA/AMBNT/STREAM                                              112WRD              04001004
                                                                 0000  CLASS 00

PARAMETER                                        NUMBER     MEAN   VARIANCE STAN DEV  COEF VAR STAND ER  MAXIMUM   MINIMUM  BEG DATE END DATE
00010  WATER        TEMP        CENT                 23  8.30435  21.9259  4.68251   .563862   .976370  18.5000   2.50000 74/10/10 75/09/10
00020   AIR         TEMP        CENT                 23  9.23912  96.7467  9.83599   1.06460   2.05095  26.0000-.599E+01 74/10/10 75/09/10
00061  STREAM       FLOW,     INST-CFS               23  11232.6 .583E+08  7639.29   .680102   1592.90  27099.9   2360.00 74/10/10 75/09/10
00070   TURB        JKSN        JTU                  23  3.21738  2.99603  1.73091   .537986   .360919  7.99999   .999999 74/10/10 75/09/10
00080  COLOR        PT-CO      UNITS                 23  4.91304  13.1739  3.62959   .738766   .756822  15.0000   .000000 74/10/10 75/09/10
00095 CNDUCTVY      AT 25C    MICROMHO               23  252.391  2749.23  52.4331   .207745   10.9331  330.000   175.000 74/10/10 75/09/10
00300    DO                    MG/L                  23  14.6304  3.67312  1.91654   .130997   .399626  17.5000   11.0000 74/10/10 75/09/10
00301    DO         SATUR     PERCENT                23  132.652  28.5170  5.34014   .040257   1.11349  144.000   124.000 74/10/10 75/09/10
00310   BOD         5 DAY      MG/L                  23  1.09565  .304074  .551429   .503290   .114981  2.30000   .400000 74/10/10 75/09/10
00400    PH                     SU                   23  8.07391  .042048  .205055   .025397   .042757  8.40000   7.70000 74/10/10 75/09/10
00405   CO2                    MG/L                  23  2.00434  1.12409  1.06023   .528966   .221073  4.10000   .700000 74/10/10 75/09/10
00410  T ALK        CACO3      MG/L                  23  108.087  263.088  16.2200   .150064   3.38210  131.000   85.0000 74/10/10 75/09/10
00440 HCO3 ION       HCO3      MG/L                  23  131.696  393.315  19.8322   .150591   4.13529  160.000   104.000 74/10/10 75/09/10
00445 CO3 ION        CO3       MG/L                  23  .000000  .000000  .000000             .000000  .000000   .000000 74/10/10 75/09/10
00605  ORG N          N        MG/L                  23  .149565  .009359  .096742   .646822   .020172  .380000   .000000 74/10/10 75/09/10
00610  NH3-N        TOTAL      MG/L                  23  .018261  .000297  .017229   .943493   .003592  .050000   .000000 74/10/10 75/09/10
00613  NO2-N         DISS      MG/L                  23  .002174  .000018  .004217   1.94001   .000879  .010000   .000000 74/10/10 75/09/10
00618  NO3-N         DISS      MG/L                  23  .076521  .003578  .059819   .781726   .012473  .230000   .000000 74/10/10 75/09/10
00625 TOT KJEL        N        MG/L                  23  .167826  .009291  .096388   .574332   .020098  .380000   .000000 74/10/10 75/09/10
00631 NO2&NO3       N-DISS     MG/L                  23  .078695  .003585  .059872   .760803   .012484  .230000   .000000 74/10/10 75/09/10
00660 ORTHOPO4       PO4       MG/L                  23  .057391  .002120  .046045   .802306   .009601  .180000   .000000 74/10/10 75/09/10
00665 PHOS-TOT                MG/L P                 23  .032609  .000266  .016298   .499795   .003398  .070000   .010000 74/10/10 75/09/10
00671 PHOS-DIS      ORTHO     MG/L P                 23  .019130  .000236  .015348   .802303   .003200  .060000   .000000 74/10/10 75/09/10
00680 T ORG C         C        MG/L                  22  4.92272  29.0227  5.38728   1.09437   1.14857  26.0000   .000000 74/10/10 75/09/10
00900 TOT HARD      CACO3      MG/L                  23  126.783  550.818  23.4695   .185116   4.89373  160.000   96.0000 74/10/10 75/09/10

STORET  DATE 77/03/29
                                                                 3006A1
                                                                48 22 00.0 115 19 10.0  4
                                                                KOOTENAI RIVER
                                                                30     LINCOLN CO MAP
                                                                O/KOOCANUSA RESERVOIR      130191
                                                                ST RT 37 BRDG 3.2 MI S OF LIBBY DAM
/TYPA/AMBNT/STREAM                                              11EPALES            04001004
                                                                 0000  CLASS 00

PARAMETER                                        NUMBER     MEAN   VARIANCE STAN DEV  COEF VAR STAND ER  MAXIMUM   MINIMUM  BEG DATE END DATE
00610  NH3-N        TOTAL      MG/L                  14  .017893  .000080  .008953   .500380   .002393  .045000   .010000 74/10/06 75/09/
00615  NO2-N        TOTAL      MG/L                   1  .001000                                        .001000   .001000 74/10/06 74/10/
00620  NO3-N        TOTAL      MG/L                   1  .068000                                        .068000   .068000 74/10/05 74/10/
00625 TOT KJEL        N        MG/L                  13  .348076  .074215  .272424   .782655   .075557  .900000   .050000 74/10/06 75/09/
00630 NO2&NO3      N-TOTAL     MG/L                  14  .062000  .001275  .035704   .575870   .009542  .135000   .010000 74/10/06 75/09/
00665 PHOS-TOT                MG/L P                 14  .031286  .000298  .017269   .551979   .004615  .070000   .010000 74/10/06 75/09/
00671 PHOS-DIS      ORTHO     MG/L P                 14  .023500  .000118  .010847   .461569   .002899  .050000   .010000 74/10/06 75/09/
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STORET  DATE 77/03/23
                                                                     05344980
                                                                    44 36 36.0 092 36 36.0  2
                                                                    MISSISSIPPI R. AT LOCK & DAM 3,
                                                                    27049 MINNESOTA
                                                                                                  070592
/TYPA/AMBNT/STREAM
                                                                    112WRD                  04001004
                                                                     0000  CLASS 00

PARAMETER                                        NUMBER     MEAN  VARIANCE STAN DEV COEF VAR STAND ER  MAXIMUM   MINIMUM  BEG DATE END DATE
00010  WATER       TEMP      CENT                    23  8.17391  84.7865  9.20796  1.12651  1.91999  25.0000   .000000 72/11/08 73/09/26
00060  STREAM      FLOW      CFS                     15  21803.3 .345E+09  18591.1  .852676  4800.21  77999.8   8100.00 72/11/08 73/09/26
00070   TURB       JKSN      JTU                     14  18.5714  293.955  17.1451  .923200  4.58223  69.9999   5.00000 72/11/08 73/09/26
00080  COLOR      PT-CO     UNITS                    14  39.2857  110.991  10.5352  .268170  2.81566  50.0000   20.0000 72/11/08 73/09/26
00095 CNDUCTVY    AT 25C    MICROMHO                 18  429.443  3635.29  60.2934  .140399  14.2113  499.999   317.000 72/11/08 73/09/26
00300    DO                  MG/L                    14  10.5428  3.10425  1.76189  .167117  .470884  12.8000   7.19999 72/11/08 73/09/26
00301    DO       SATUR     PERCENT                   8  79.3886  1202.92  34.6832  .436879  12.2624  111.000   .110000 73/01/17 73/09/26
00310   BOD       5 DAY      MG/L                    13  3.49615  3.03314  1.74159  .498146  .483030  6.39999   1.45000 72/11/08 73/09/26
00400    PH                   SU                     15  7.98666  .112723  .335743  .042038  .086688  8.69999   7.60000 72/11/08 73/09/26
00405   CO2                  MG/L                    11  4.76363  6.80454  2.60855  .547597  .786508  8.50000   1.10000 72/11/28 73/09/26
00410  T ALK      CACO3      MG/L                    13  157.615  313.432  17.7040  .112324  4.91021  183.000   123.000 72/11/08 73/09/26
00440 HCO3 ION     HCO3      MG/L                    11  196.727  961.425  31.0068  .157613  9.34892  253.000   150.000 72/11/28 73/09/26
00445 CO3 ION      CO3       MG/L                    11  .000000  .000000  .000000           .000000  .000000   .000000 72/11/28 73/09/26
00550 OIL-GRSE   TOT-SXLT    MG/L                     2  9.50000  144.500  12.0208  1.26535  8.50000  18.0000   1.00000 72/11/28 73/05/07
00600 TOTAL N        N       MG/L                     1  3.00000                                      3.00000   3.00000 72/11/22 72/11/22
00605  ORG N         N       MG/L                    12  1.11667  .184514  .429552  .384673  .124001  1.90000   .380000 72/11/22 73/09/26
00608  NH3-N       DISS      MG/L                     4  .532500  .053625  .231572  .434876  .115786  .860000   ,350000 72/11/22 73/01/17
00610  NH3-N      TOTAL      MG/L  <-------->        12  .464166  .046518  .215680  .464660  .062261  .900001   .250000 72/11/22 73/09/26
00613  NO2-N       DISS      MG/L                    12  .025000  .000300  .017321  .692821  .005000  .060000   .000000 72/11/22 73/09/26
00618  NO3-N       DISS      MG/L                    12  2.21083  9.98688  3.16020  1.42942  .912272  12.0000   .330000 72/11/22 73/09/26
00625 TOT KJEL       N       MG/L  <-------->        12  1.58583  .171323  .413912  .261006  .119486  2.50000   .730001 72/11/22 73/09/26
00631 NO2&NO3     N-DISS     MG/L                    12  2.22166  9.94454  3.15350  1.41943  .910336  12.0000   .370000 72/11/22 73/09/26
00665 PHOS-TOT              MG/L P <-------->         1  .190000                                      .190000   .190000 72/11/22 72/11/22
00666 PHOS-DIS              MG/L P                   11  .154545  .009947  .099737  .645357  .030072  .400000   .050000 72/11/28 73/09/26
00720 CYANIDE     CN-TOT     MG/L                     2  .000000  .000000  .000000           .000000  .000000   .000000 72/11/28 73/05/07

STORET  DATE 77/03/28
                                                                    27A4A6          LS27A4A6
                                                                    44 36 30.0 092 36 30.0  4
                                                                    MISSISSIPPI RIVER
                                                                    27    15 RED WING
                                                                    T/LAKE PEPIN                  070592
/TYPA/AMBNT/STREAM                                                  AT LOCK & DAM 3 5 MI NW REDWING, MN
                                                                    11EPALES                04001004
                                                                     0000  CLASS 00

PARAMETER                                        NUMBER     MEAN  VARIANCE STAN DEV COEF VAR STAND ER  MAXIMUM   MINIMUM  BEG DATE END DATE
00610  NH3-N      TOTAL      MG/L  <-------->        13  .338615  .048620  .220500  .651183  .061156  .690000   .042000 72/10/14 73/09/0-
00615  NO2-N      TOTAL      MG/L                    13  .027615  .000177  .013295  .481435  .003687  .051000   .014000 72/10/14 73/09/0-
00620  NO3-N      TOTAL      MG/L                    13  1.32423  .994174  .997083  .752954  .276541  3.25000   .140000 72/10/14 73/09/0-
00625 TOT KJEL       N       MG/L  <-------->        13  1.88615  .261070  .510950  .270896  .141712  3.00000   1.00000 72/10/14 73/09/0-
00630 NO2&NO3    N-TOTAL     MG/L                    13  1.34346  .985374  .992660  .738883  .275314  3.30000   .168000 72/10/14 73/09/0-
00665 PHOS-TOT              MG/L P <-------->        13  .209230  .001066  .032652  .156057  .009056  .250000   .155000 72/10/14 73/09/0-
00671 PHOS-DIS    ORTHO     MG/L P                   13  .104692  .001614  .040180  .383789  .011144  .170000   .044000 72/10/14 73/09/0-
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STORET  DATE 77/03/28
                                                                     05331580
                                                                    44 44 48.0 092 51 08.0  2
                                                                    MISSISSIPPI R BL L & D 2 AT HAST
                                                                    27037 MINNESOTA
                                                                                                 070591
/TYPA/AMBNT/STREAM
                                                                    112WRD               04001004
                                                                     0000  CLASS 00

PARAMETER
                                                 NUMBER    MEAN   VARIANCE STAN DEV COEF VAR STAND ER MAXIMUM   MINIMUM  BEG DATE END DATE
00010  WATER      TEMP       CENT                    19  7.63157  66.4678  8.15278  1.06830  1.87037  26.0000   .000000 72/11/28 73/09/19
00060  STREAM     FLOW       CFS                     13  15953.8 .177E+09  13338.8  .836087  3699.51  49999.9   4500.00 72/11/28 73/09/19
00070   TURB      JKSN       JTU                     13  19.3077  171.398  13.0919  .678067  3.63104  50.0000   5.00000 72/11/28 73/09/19
00080  COLOR      PT-CO      UNITS                   11  37.2727  81.8195  9.04541  .242682  2.72729  50.0000   20.0000 72/11/28 73/09/19
00095 CNDUCTVY    AT 25C     MICROMHO                16  525.874  5300.40  72.8038  .138443  18.2010  607.000   386.000 72/11/28 73/09/19
00300    DO                  MG/L                    14  10.6428  5.15963  2.27148  .213428  .607079  13.6000   6.79999 72/11/28 73/09/19
00301    DO       SATUR      PERCENT                 10  92.3998  119.833  10.9468  .118472  3.46169  120.000   81.9999 72/11/30 73/09/19
00310   BOD       5 DAY      MG/L                    12  3.94999  .952774  .976101  .247115  .281776  5.79999   2.00000 72/11/28 73/09/19
00400    PH                  SU                      13  7.92307  .085246  .291969  .036850  .080977  8.59999   7.40000 72/11/28 73/09/19
00405   CO2                  MG/L                    10  6.29999  19.3111  4.39444  .697531  1.38964  17.0000   2.50000 72/11/28 73/09/19
00410  T ALK      CACO3      MG/L                    10  189.700  1261.58  35.5187  .187236  11.2320  233.000   131.000 72/11/28 73/09/19
00440 HCO3 ION    HCO3       MG/L                    10  231.300  1866.69  43.2052  .186793  13.6627  284.000   160.000 72/11/28 73/09/19
00445 CO3 ION     CO3        MG/L                    10  .000000  .000000  .000000           .000000  .000000   .000000 72/11/28 73/09/19
00550 OIL-GRSE    TOT-SXLT   MG/L                     2  16.5000  480.500  21.9203  1.32850  15.5000  32.0000   1.00000 72/11/28 73/05/07
00605  ORG N      N          MG/L                    10  1.19600  .134049  .366127  .306126  .115780  1.80000   .650001 72/11/28 73/09/19
00608  NH3-N      DISS       MG/L                     3  .883333  .085834  .292974  .331669  .169149  1.10000   .550000 72/11/28 73/01/17
00610  NH3-N      TOTAL      MG/L                    10  .693000  .153912  .392316  .566113  .124061  1.20000   .110000 72/11/28 73/09/19
00613  NO2-N      DISS       MG/L                    10  .026000  .000293  .017127  .658731  .005416  .050000   .000000 72/11/28 73/09/19
00618  NO3-N      DISS       MG/L                    10  2.46300  5.73744  2.39529  .972512  .757459  8.60000   .170000 72/11/28 73/09/19
00625 TOT KJEL    N          MG/L                    10  1.89000  .165446  .406750  .215212  .128626  2.60000   1.20000 72/11/28 73/09/19
00631 NO2&NO3     N-DISS     MG/L                    10  2.47200  5.69517  2.38646  .965396  .754664  8.60000   .210000 72/11/28 73/09/19
00666 PHOS-DIS               MG/L P                  10  .199000  .011210  .105878  .532052  .033482  .340000   .060000 72/11/28 73/09/19
00720 CYANIDE     CN-TOT     MG/L                     2  .010000  .000200  .014142  1.41421  .010000  .020000   .000000 72/11/28 73/05/07
00900 TOT HARD    CACO3      MG/L                    10  250.000  1711.11  41.3656  .165462  13.0809  300.000   180.000 72/11/28 73/09/19
00902 NC HARD     CACO3      MG/L                    10  59.6000  1283.60  35.8274  .601131  11.3296  130.000   15.0000 72/11/28 73/09/19

STORET  DATE 77/03/28
                                                                     27A4A4          LS27A4A4
                                                                    44 45 00.0 092 51 00.0  4
                                                                    MISSISSIPPI RIVER
                                                                    27     15 HASTINGS
                                                                    T/LAKE PEPIN                070591
/TYPA/AMBNT/STREAM                                                  US 61 BRDG N HASTINGS ABOVESTP
                                                                    11EPALES               04001004
                                                                     0000  CLASS 00

PARAMETER
                                                 NUMBER    MEAN   VARIANCE STAN DEV COEF VAR STAND ER MAXIMUM   MINIMUM  BEG DATE END DATE
00610  NH3-N      TOTAL      MG/L                    11  .337090  .054846  .234192  .694746  .070612  .740000   .032000 72/10/14 73/09/22
00615  NO2-N      TOTAL      MG/L                    11  .024955  .000227  .015051  .603124  .004538  .054000   .004000 72/10/14 73/09/22
00620  NO3-N      TOTAL      MG/L                    11  1.78245  1.04386  1.02169  .573196  .308052  2.80000   .231000 72/10/14 73/09/22
00625 TOT KJEL    N          MG/L                    11  1.77636  .078006  .279295  .157229  .084211  2.10000   1.26000 72/10/14 73/09/22
00630 NO2&NO3     N-TOTAL    MG/L                    11  1.80109  1.04171  1.02064  .566682  .307736  2.90000   .260000 72/10/14 73/09/22
00665 PHOS-TOT               MG/L P                  11  .254545  .004647  .068172  .267817  .020555  .370000   .170000 72/10/14 73/09/22
00671 PHOS-DIS    ORTHO      MG/L P                  11  .135909  .004290  .065501  .481945  .019749  .250000   .034000 72/10/14 73/09/22
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STORET  DATE 77/03/21
                                                                06862000
                                                                38 47 30.0 099 43 20.0  2
                                                                SMOKY HILL R AT CEDAR BLUFF DAM.
                                                                20195 KANSAS

/TYPA/AMBNT/STREAM                                              112WRD              04001004
                                                                 0000  CLASS 00

PARAMETER                                      NUMBER    MEAN  VARIANCE STAN DEV COEF VAR STAND ER MAXIMUM  MINIMUM  BEG DATE END DATE
00010  WATER        TEMP       CENT                16  15.9375  78.2286  8.84469  .554962  2.21117  28.0000  2.50000 74/10/16 75/09/16
00027  COLLECT     AGENCY      CODE                12  1028.00  3.09091  1.75810  .001710  .507519  1028.00  1028.00 74/10/16 75/09/16
00028  ANALYZE     AGENCY      CODE                12  9719.96  372.364  19.2967  .001985  5.57048  9719.98  9719.98 74/10/16 75/09/16
00061  STREAM       FLOW.    INST-CFS              12  2.19966  3.85236  1.96274  .892293  .566595  7.89999  .196000 74/10/16 75/09/16
00070   TURB        JKSN       JTU                 16  3.37499  8.91668  2.98608  .884767  .746520  9.99999  .999999 74/10/16 75/09/16
00095 CNDUCTVY     AT 25C    MICROMHO              16  1186.25  5624.53  74.9969  .063222  18.7492  1390.00  1050.00 74/10/16 75/09/16
00400    PH                    SU                  16  7.78124  .061621  .248236  .031902  .062059  8.29999  7.29999 74/10/16 75/09/16
00405   CO2                   MG/L                 12  5.09166  2.68810  1.63954  .322005  .473295  8.00000  2.80000 74/10/16 75/09/16
00410   T ALK       CACO3     MG/L                 12  118.250  186.386  13.6523  .115453  3.94109  139.000  82.0000 74/10/16 75/09/16
00440  HCO3 ION     HCO3      MG/L                 12  144.166  281.057  16.7647  .116287  4.83956  170.000  99.9998 74/10/16 75/09/16
00445  CO3 ION      CO3       MG/L                 12  .000000  .000000  .000000           .000000  .000000  .000000 74/10/16 75/09/16
00618   NO3-N       DISS      MG/L                 12  .047500  .000420  .020505  .431685  .005919  .090000  .020000 74/10/16 75/09/16
00650   T PO4       PO4       MG/L                 12  .139999  .003236  .056890  .406356  .016423  .280000  .090000 74/10/16 75/09/16
00665 PHOS-TOT                MG/L P  <---->       12  .046667  .000297  .017233  .369275  .004975  .090000  .030000 74/10/16 75/09/16
00900  TOT HARD     CACO3     MG/L                 12  530.832  591.000  24.3105  .045797  7.01783  570.000  469.999 74/10/16 75/09/16
00902  NC HARD      CACO3     MG/L                 12  411.666  197.000  14.0357  .034095  4.05175  430.000  380.000 74/10/16 75/09/16

STORET  DATE 77/03/21
                                                               2001A1
                                                               38 47 30.0 099 43 20.0  4
                                                               SMOKY HILL RIVER
                                                               20    TREGO CO HWY MAP
                                                               O/CEDAR BLUFF RESERVOIR
                                                               BANK SAMPLE NEAR BASE OF DAM
/TYPA/AMBNT/STREAM                                             11EPALES            04001004
                                                                0000  CLASS 00

PARAMETER                                      NUMBER    MEAN  VARIANCE STAN DEV COEF VAR STAND ER MAXIMUM  MINIMUM  BEG DATE END DATE
00610  NH3-N       TOTAL      MG/L                 14  .037464  .000424  .020599  .549835  .005505  .090000  .020000 74/10/13 75/09/1
00615  NO2-N       TOTAL      MG/L                  1  .004000                                      .004000  .004000 74/10/13 74/10/1
00620  NO3-N       TOTAL      MG/L                  1  .008000                                      .008000  .008000 74/10/13 74/10/1
00625 TOT KJFL       N        MG/L                 14  1.33571  1.22440  1.10652  .828415  .295731  4.40000  .450000 74/10/13 75/09/1
00630 NO2&NO3     N-TOTAL     MG/L                 14  .042786  .015856  .125919  2.94302  .033653  .480000  .005000 74/10/13 75/09/1
00665 PHOS-TOT                MG/L P  <---->       14  .039464  .000623  .024965  .632597  .006672  .100000  .010000 74/10/13 75/09/1
00671 PHOS-DIS     ORTHO      MG/L P               14  .007607  .000007  .002603  .342192  .000696  .012500  .005000 74/10/13 75/09/1
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STORET  DATE 77/03/28
                                                          01431670
                                                          41 22 04.0 075 19 10.0  2
                                                          WALLENPAUPACK CREEK AT LEDGEDALE
                                                          42103 PENNSYLVANIA
                                                                                020391
/TYPA/AMBNT/STREAM
                                                          112WRD               04001004
                                                           0000  CLASS 00

PARAMETER                                      NUMBER    MEAN  VARIANCE STAN DEV COEF VAR STAND ER MAXIMUM  MINIMUM  BEG DATE END DATE
00008   LAB        IDENT.       NUMBER              8 1404916 .156E+14  3957814  2.81712  1399298 .111E+08  .849999 73/06/20 74/04/17
00010  WATER        TEMP         CENT              12 10.8333  90.1512  9.49480  .876445  2.74091  25.0000  .000000 73/06/20 74/04/17
00020   AIR         TEMP         CENT              12 14.5833  76.9922  8.77452  .601682  2.53298  25.0000  .999999 73/06/20 74/04/17
00060  STREAM       FLOW          CFS              11 368.417   124294  352.554  .956941  106.299  1200.00  51.9999 73/07/25 74/04/17
00061  STREAM       FLOW.      INST-CFS            11 368.454   124272  352.523  .956763  106.290  1200.00  51.9999 73/07/25 74/04/17
00065  STREAM      STAGE         FEET               1 15.1000                                      15.1000  15.1000 73/06/20 73/06/20
00095 CNDUCTVY     AT 25C      MICROMHO            12 65.1665  82.7113  9.09457  .139559  2.62538  84.9999  52.9999 73/06/20 74/04/17
00300    DO                      MG/L              11 10.3818  5.24372  2.28992  .220570  .690436  14.2000  6.79999 73/06/20 74/04/17
00301    DO        SATUR       PERCENT             11 94.2725  48.2250  6.94442  .073663  2.09382  103.000  77.9999 73/06/20 74/04/17
00310   BOD        5 DAY         MG/L               9 2.50000  8.63999  2.93939  1.17576  .979795  9.69999  .000000 73/06/20 74/04/17
00400    PH                       SU               11 6.73635  .160571  .400713  .059485  .120820  7.49999  6.19999 73/06/20 74/04/17
00405   CO2                      MG/L              11 4.80909  9.82692  3.13479  .651848  .945175  11.0000  .700000 73/06/20 74/04/17
00410  T ALK       CACO3         MG/L              11 11.4545  16.6727  4.08323  .356472  1.23114  20.0000  6.00000 73/06/20 74/04/17
00440 HCO3 ION      HCO3         MG/L              11 13.8182  23.5636  4.85424  .351294  1.46361  24.0000  6.99999 73/06/20 74/04/17
00445 CO3 ION       CO3          MG/L              11 .000000  .000000  .000000           .000000  .000000  .000000 73/05/20 74/04/17
00500 RESIDUE      TOTAL         MG/L              11 52.9998  75.8121  8.70701  .164284  2.62526  69.9999  40.9999 73/06/20 74/04/17
00530 RESIDUE     TOT NFLT       MG/L              11 6.54544  19.0727  4.36723  .667217  1.31677  18.0000  2.00000 73/06/20 74/04/17
00600 TOTAL N        N           MG/L               6 .443333  .031307  .176938  .399108  .072235  .720000  .220000 73/10/15 74/03/21
00605  ORG N         N           MG/L              10 .185000  .024672  .157074  .849052  .049671  .420000  .000000 73/06/20 74/03/21
00608  NH3-N        DISS         MG/L               4 .062500  .002692  .051881  .830101  .025941  .140000  .030000 73/06/20 73/09/18
00610  NH3-N       TOTAL         MG/L               6 .078333  .001257  .035449  .452547  .014472  .140000  .050000 73/10/15 74/03/21
00613  NO2-N        DISS         MG/L               4 .003250  .000002  .001500  .461538  .000750  .005000  .002000 73/06/20 73/09/18
00615  NO2-N       TOTAL         MG/L               7 .004000  .000019  .004359  1.08973  .001648  .010000  .000000 73/10/15 74/04/17
00618  NO3-N        DISS         MG/L               4 .047500  .000892  .029861  .628649  .014930  .080000  .010000 73/06/20 73/09/18
00620  NO3-N       TOTAL         MG/L               7 .278571  .021014  .144963  .520382  .054791  .470000  .030000 73/10/15 74/04/17
00625 TOT KJEL       N           MG/L               9 .242222  .020420  .142897  .589944  .047632  .459999  .100000 73/07/25 74/03/21
00630 NO2&NO3     N-TOTAL        MG/L               7 .281428  .021214  .145652  .517546  .055051  .469999  .030000 73/10/15 74/04/17
00631 NO2&NO3      N-DISS        MG/L               4 .050000  .000867  .029439  .588785  .014720  .080000  .010000 73/06/20 73/09/18
00660 ORTHOPO4      PO4          MG/L              11 .016364  .000225  .015015  .917593  .004527  .040000  .000000 73/06/20 74/04/17
00665 PHOS-TOT                   MG/L P            11 .017636  .000069  .008298  .470502  .002502  .030000  .007000 73/06/20 74/04/17
00671 PHOS-DIS     ORTHO         MG/L P            11 .005545  .000022  .004719  .851039  .001423  .012000  .000000 73/06/20 74/04/17
                                                           4229A2
                                                          41 22 02.0 075 19 14.0  4
                                                          WALLENPAUPACK CREEK
                                                          42     7.5 NEWFOUNDLAND
                                                          I/LAKE WALLENPAUPACK      020391
                                                          AT BANK .3 MI E OF LEDGEDALE
/TYPA/AMBNT/STREAM                                        11EPALES             04001004
                                                           0000  CLASS 00

PARAMETER                                      NUMBER    MEAN  VARIANCE STAN DEV COEF VAR STAND ER MAXIMUM  MINIMUM  BEG DATE END DATE
00610  NH3-N       TOTAL        MG/L               12 .063167  .003524  .059364  .939807  .017137  .189000  .010000 73/05/19 74/04/23
00615  NO2-N       TOTAL        MG/L               12 .001333 .242E-06  .000492  .369277  .000142  .002000  .001000 73/05/19 74/04/23
00620  NO3-N       TOTAL        MG/L               12 .176250  .017949  .133974  .760136  .038675  .368000  .011000 73/05/19 74/04/23
00625 TOT KJEL       N          MG/L               12 .652916  .110311  .332131  .508689  .095878  1.30000  .200000 73/05/19 74/04/23
00630 NO2&NO3     N-TOTAL       MG/L               12 .177416  .017770  .133304  .751362  .038482  .368000  .012000 73/05/19 74/04/23
00665 PHOS-TOT                  MG/L P             11 .024864  .000065  .008075  .324771  .002435  .040000  .010000 73/05/19 74/04/23
00671 PHOS-DIS     ORTHO        MG/L P             12 .006417  .000003  .001832  .285499  .000529  .010000  .005000 73/05/19 74/04/23
```

In 1971, the Illinois EPA collected from 2 to 7 samples at nine comparable sampling sites on seven streams from which the NES obtained from 9 to 14 samples during the period of June, 1973 through May, 1974. There is quite good agreement between IL EPA and NES total phosphorus data considering the difference in times of collection (excluding one obviously different data pair, the mean of all IL EPA TP data is 155 µg/l and the mean of all NES data is 157 µg/l; the coefficient of rank correlation is 0.78, n = 8).

In 1973-74, the Wisconsin DNR collected 3 or 4 samples at 11 stream sites from which the NES collected from 11 to 14 samples during the period of September, 1972 through September, 1973 (28 of the 38 DNR samples were taken after NES sampling was completed). There is very good agreement between DNR and NES total phosphorus data (excluding one obviously different data pair, the mean of all DNR TP data is 122 µg/l and the mean of NES data is 134 µg/l; the coefficient of rank correlation is 0.88, n = 10). However, the agreement between DNR and NES total nitrogen data is not as good (excluding two obviously different data pairs, the mean of all DNR data is 1,643 µg/l and the mean of all NES data is 1,816 µg/l; the coefficient of rank correlation is 0.65, n = 9).

Finally, data obtained at several of the NES analytical quality control stations were evaluated. Control stations were those at which two separate samples were taken, usually at the same time by the same National Guard sampling team, but a few such stations were sampled by different teams on different days. For the most part, one of the sample pairs was an inlet sample for one water body and the other sample was an outlet sample for another water body, so the two samples had different identifiers (STORET code) and could not readily be detected as control samples by the analysts at CERL.

One example of a control station on the Wichita River in Texas is shown on the following page. It will be noted that though the sampling locations are identical, one set is identified as the inlet of Lake Diversion, and the other set is identified as the outlet of Lake Kemp. Also it will be noted that the data essentially are identical considering the precision limits of the analytical methods and the extra "outlet" sample.

Comparisons of six other sets of analytical quality control data are on file at CERL; and in all cases, the data are as nearly identical as in the example shown.

```
STORET  DATE 77/04/11
                                                                      4812A2
                                                                      33 45 37.0 099 08 30.0  4
                                                                      WICHITA RIVER
                                                                      48     7.5 NE LK KEMP
                                                                      T/LAKE DIVERSION          101591
/TYPA/AMBNT/STREAM                                                    HWY 183/283 BRDG BELO LAKE KEMP DAM
                                                                      11EPALES              04001004
                                                                       0000  CLASS 00

PARAMETER                                           NUMBER    MEAN   VARIANCE  STAN DEV  COEF VAR  STAND ER  MAXIMUM   MINIMUM  BEG DATE END DATE
00610  NH3-N        TOTAL          MG/L                 7  .035714   .000395   .019881   .556658   .007514   .075000   .020000  74/09/07 75/08/22
00615  NO2-N        TOTAL          MG/L                 2  .009500   .000084   .009192   .967619   .006500   .016000   .003000  74/09/07 74/10/31
00620  NO3-N        TOTAL          MG/L                 3  .174667   .049669   .222866   1.27595   .128672   .432000   .044000  74/09/07 74/11/16
00625 TOT KJEL        N            MG/L                 7  .664285   .063929   .252842   .380622   .095565   1.20000   .400000  74/09/07 75/08/22
00630 NO2&NO3      N-TOTAL         MG/L                 7  .038143   .000588   .024259   .635991   .009169   .080000   .005000  74/09/07 75/08/22
00665 PHOS-TOT                     MG/L P               6  .031667   .000057   .007528   .237721   .003073   .040000   .020000  74/09/07 75/08/22
00671 PHOS-DIS      ORTHO          MG/L P               7  .008571   .000031   .005563   .649073   .002103   .020000   .005000  74/09/07 75/08/22


STORET  DATE 77/04/13
                                                                      4816A1
                                                                      33 45 37.0 099 08 30.0  4
                                                                      WICHITA RIVER
                                                                      48     7.5 NE LAKE KEMP
                                                                      O/LAKE KEMP                101591
/TYPA/AMBNT/STREAM                                                    183/283 BRDG BELO DAM
                                                                      11EPALES              04001004
                                                                       0000  CLASS 00

PARAMETER                                           NUMBER    MEAN   VARIANCE  STAN DEV  COEF VAR  STAND ER  MAXIMUM   MINIMUM  BEG DATE END DATE
00610  NH3-N        TOTAL          MG/L                 8  .046250   .000741   .027223   .588598   .009625   .085000   .020000  74/09/07 75/1[illegible]/22
00615  NO2-N        TOTAL          MG/L                 3  .008000   .000048   .006928   .866024   .004000   .016000   .004000  74/09/07 74/[illegible]/31
00620  NO3-N        TOTAL          MG/L                 3  .184000   .065856   .256624   1.39470   .148162   .480000   .024000  74/09/07 74/[illegible]/31
00625 TOT KJEL        N            MG/L                 8  .687500   .104822   .323762   .470926   .114467   1.40000   .350000  74/09/07 75/[illegible]/22
00630 NO2&NO3      N-TOTAL         MG/L                 8  .039500   .000490   .022142   .560567   .007829   .075000   .005000  74/09/07 75/1[illegible]/22
00665 PHOS-TOT                     MG/L P               7  .034286   .000095   .009759   .284639   .003689   .050000   .020000  74/09/07 75/1[illegible]/22
00671 PHOS-DIS      ORTHO          MG/L P               8  .007500   .000029   .005345   .712696   .001890   .020000   .005000  74/09/07 75/1[illegible]/22
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E. Tributary Nutrient Loads -

In our evaluation of nutrient loads in streams, we have restricted comparisons to loads reported by others which we assume were determined by direct measurement. Unfortunately, with only one exception, the NES working papers are the only reports we have reviewed in which the method of calculation of loadings is stated or at least referenced. Because of this and a general uncertainty as to the sources of flow data (U.S.G.S. or independently gaged, metered, or estimated in one or more ways), we are by far more dubious about the comparability of stream nutrient loads (and wastewater treatment plant effluent loads; section F, below) than any of the other measurements made during the Survey.

Considering the good agreement between the NES stream nutrient concentrations and those of others demonstrated in the preceding section, it would be expected that equally good agreement can be shown for nutrient loads provided sampling times are comparable, the frequency of sampling is similar, the flows essentially are identical, and the same method of calculation is used. However, in one case (Campbell and Dean, 1976), using the concentrations and flows given, we calculated a total phosphorus load for one stream that is 63% less than the load reported; but for another stream, our calculated TP load is 54% less than the reported load. Obviously, some unknown weighting factor was incorporated in the calculation of the reported loads. It is equally obvious that if some of the raw data had not been included in that report, the weighting factor would not have been detected, and a spurious comparison of nutrient loads would have resulted.

It should be noted that flows are equally as important as nutrient concentrations in the determination of nutrient loads, so some differences in loadings would be expected because of flow differences. For example, the U.S. Geological Survey submitted limits of accuracy of the gaged and estimated flows they provided for the NES-sampled tributaries, and the limits of accuracy of gaged flows of tributaries sampled in 1972 varied from ±5% to ±15% (one extreme of ±50%); i.e., as much as 30% difference in calculated nutrient loads could have resulted solely from the limits of accuracy of the gaged flows, and the limits of accuracy of flows measured or estimated by others are not likely to be as good as those attained by U.S.G.S.

Because of the scarcity of reported nutrient loadings and the uncertainties noted above, data comparisons necessarily will be less extensive than in other sections of this report.

In the following table, three years of loading data reported by Weiss and Moore (1975) for three gaged tributaries and two years of data for the gaged outlet of John H. Kerr Reservoir, VA and NC, were compared with NES loadings. The Weiss-Moore loads were reported as mean daily loads (in kg) based on monthly samples and were extrapolated to yearly loads; the NES loads were calculated using mean annual concentrations and mean annual flows.

River	Data Source & Period	No. Samples	Mean Flow (m^3/sec)	TP Load (kg/yr)	TN Load (kg/yr)
Roanoke	W-M, 7/72-3/73	8	98.780	221,920	1,598,700
	W-M, 4/73-3/74	11	104.982	191,260	2,005,675
	W-M, 4/74-3/75	12	77.172	209,510	1,185,520
	NES, 7/73-6/74	15	82.460	205,435	3,123,150
Banister	W-M, 7/72-3/73	8	15.916	18,615	240,535
	W-M, 4/73-3/74	11	15.463	23,360	304,045
	W-M, 4/74-3/75	12	17.417	26,645	321,200
	NES, 7/73-6/74	14	14.800	32,205	578,750
Dan	W-M, 7/72-3/73	8	78.418	279,225	1,451,605
	W-M, 4/73-3/74	11	83.091	428,510	2,301,690
	W-M, 4/74-3/75	12	79.381	354,050	2,106,050
	NES, 7/73-6/74	13	68.100	466,030	2,920,740
Outlet (Roanoke)	W-M, 9/73-3/74	6	210.276	201,845	4,200,785
	W-M, 4/74-3/75	12	250.887	377,045	4,026,680
	NES, 7/73-6/74	15	197.800	149,710	6,699,420

Considering the differences in sampling periods, flows, numbers of samples, and methods of calculation, the NES data compare quite well (note the between-year differences in the Weiss-Moore loads).

Another example of between-year loading differences is shown in the following table where the NES data are compared with data reported by Wright and Soltero (1973) for two tributaries and the outlet of Yellowtail Reservoir, MT and WY. The nutrient loads in both cases were calculated using mean annual concentrations and mean annual flows. Again considering differences, particularly sampling times, the Wright-Soltero 1969 loads compare quite well with the NES loads.

River	Data Source & Period	No. Samples	Mean Flow (m^3/sec)	TP Load (kg/yr)	TN Load (kg/yr)
Bighorn	W-S, 1/68-12/68	19	72.384	1,524,845	3,145,565
	W-S, 1/69-12/69	27	72.414	589,180	3,459,725
	NES, 10/74-9/75	10	64.660	656,595	3,085,185
Shoshone	W-S, 1/68-12/68	19	28.388	189,790	1,540,715
	W-S, 1/69-12/69	27	31.094	201,020	1,746,415
	NES, 10/74-9/75	13	29.480	383,960	1,934,665
Outlet (Bighorn)	W-S, 1/68-12/68	19	117.916	122,715	4,741,215
	W-S, 1/69-12/69	27	94.953	86,840	3,455,580
	NES, 10/74-9/75	8	100.780	66,740	5,075,580

Wright et al. (1974) reported total phosphorus loads in the Missouri River inlet of Canyon Ferry Reservoir, MT, for four months of sampling (May-September) in 1971 and 1972. The reported loads were extrapolated to a full year and are compared to the NES total phosphorus load measured during the period of 10/74 through 8/75 (calculated using mean annual concentrations and flows).

Data Source & Year	No. Samples	TP Load (kg/yr)
W - 1971	16	405,510
W - 1972	16	347,030
NES - 1974-75	13	370,080

Hydroscience, Incorporated (Anonymous, 1974), reported nutrient and flow data obtained by the U.S. Geological Survey at a station on the West Branch of the Delaware River, NY, during the period of 05/73 through 04/74. The same station was sampled by the NES during the period of 11/72 through 04/73. The nutrient loads compared below were calculated using the reported mean annual concentrations and flows.

No. Samples		Total P (kg/yr)		Total N (kg/yr)	
U.S.G.S	NES	U.S.G.S.	NES	U.S.G.S.	NES
11	14	82,405	81,235	498,110	726,055

In a U.S. Geological Survey publication, Goolsby and McPherson (1970) reported nutrient concentrations and flows for the St. Johns River outlet of Lake Poinsett, FL, obtained during the period of 07/69 through 07/70. The same station was sampled by the NES during the period of 03/73 through 02/74. The nutrient loads compared below were calculated using the means of the reported concentrations and flows.

No. Samples		Total P (kg/yr)		Total N (kg/yr)	
U.S.G.S.	NES	U.S.G.S.	NES	U.S.G.S.	NES
6	11	82,540	75,045	1,907,445	1,801,035

Agena (1975) reported nutrient and flow data obtained at a station on the South Fork Chariton River, IA, during the period of 03/71 through 11/72. The same station was sampled by the NES during the period of 08/74 through 07/75. The nutrient loads shown below were calculated using the means of the reported concentrations and flows.

No. Samples		Total P (kg/yr)		Total N (kg/yr)	
A	NES	A	NES	A	NES
25	14	17,195	20,150	217,370	176,915

Brye (1970) reported the sums of all total phosphorus and total nitrogen inputs to and the loads in the outflows of two TVA reservoirs in Tennessee based on data obtained during calendar year 1968. In the next table, the TVA loads are compared with NES loads that are based on data obtained during the period of 04/73 through 03/74.

Cherokee Reservoir

Agency	Total P (kg/yr)		Total N (kg/yr)	
	Inputs	Outflow	Inputs	Outflow
TVA	426,305	131,520	11,682,540	8,027,210
NES	469,800	174,735	6,826,440	6,402,390

Douglas Reservoir

TVA	789,155	190,475	6,598,640	4,716,555
NES	682,370	286,690	9,126,655	7,702,060

Overall, the NES loadings compare quite well to those reported by others considering variables such as flows, times of sampling, and methods of calculation.

A further appraisal of the NES nutrient loadings involves the apparent loss of nitrogen, phosphorus (less frequently), or both nutrients (rarely) from some of the water bodies surveyed. Usually, but not invariably, the apparent nitrogen losses occurred at water bodies with mean hydraulic retention times of less than 40 days, and losses of both nitrogen and phosphorus occurred at water bodies with retention times of less than ten days.

While nitrogen washout could occur as a result of nitrogen fixation in the water bodies, and phosphorus washout would be possible, for example, if point-source inputs had been reduced or eliminated in the recent past, the limits of accuracy of flow measurements noted above could have resulted in many of the nutrient imbalances; e.g., at 90% of the water bodies surveyed in 1972 where nutrient loss occurred, the loss can be accounted for by the accuracy of the flow data (i.e., the percent loss is less than the range of the accuracy limits of flows). However, the magnitude of loss at the six remaining water bodies indicates other factors were involved, but the probable causes of the losses can be identified with some degree of confidence for five of the six.

In regard to nitrogen losses, it is noted that such losses occurred at Shagawa Lake, MN, in three of the six years for which loadings were reported by Malueg et al. (1975), although tributary sampling there was much more intensive than was possible during the Survey (loads in the Shagawa and Burntside rivers were determined from weekly nutrient samples and daily flows; loads in the creeks, where no relationship could be established for nutrient concentrations vs. flow, were calculated using mean nutrient concentrations for a month and the total flow for that month). Shagawa Lake has a mean hydraulic retention time of nine months.

Further consideration of the NES tributary phosphorus concentrations, loads, and losses involves sampling frequency, particularly with respect to smaller streams. Some recent studies have shown that a large proportion of the phosphorus export of smaller watersheds is associated with short-term periods of peak runoff; and in other studies reviewed, frequency of sampling and continuous vs. discontinuous flow measurements for the determination of phosphorus loads in small and medium-sized streams were evaluated.

Treunert et al. (1974) used total phosphorus concentrations obtained from sampling a small stream (mean flow of about 1.1 m^3/sec) described as draining an agricultural area with scattered settlements (presumably, there are no point sources in the drainage since the authors note the stream does not show distinct daily variations of nitrogen and phosphorus concentrations, and no mention of point sources is made anywhere in their report).

The stream was sampled approximately every three days in 1968 (111 samples in 366 days) with continuous flow measurements during that period to compare various sampling frequencies and continuous vs. discontinuous total daily flow measurements. To obtain a base or reference load, 266 fictive TP concentrations were added to the data base by interpolating concentration values for the days no samples were taken; the daily measured or interpolated concentrations were then multiplied by the respective total daily flows, and the sum of the daily loads for the year was used as the reference total phosphorus annual load. The sum of the total daily flows provided the reference annual total flow.

The authors then simulated sampling using intervals of from one day to 29 days; varied the starting day for sampling intervals of three days and longer to provide a number of sampling sequences (e.g., with a seven-day interval, varying the starting day from the first to the second day, and so on, provided seven different sampling series for the year); and compared the simulated annual TP loads and annual flows with the reference load and the reference flow.

From the results of their comparisons, the authors concluded that with continuous flow measurements, the sampling frequency for small streams could be extended to 28 days if a mean of the differences of annual loads from a reference load (the sum of daily concentrations X total daily flows) of 20% is acceptable as well as a maximum difference of about 40%. They also concluded that if the maximum difference is not to exceed 20%, a sampling frequency of from 14 to 21 days is necessary.

A similar study was conducted by Unger (1970) on a larger stream (mean flow of 18.6 m^3/sec) with point sources in the drainage. He collected daily 24-hour composited samples (subsamples every 30 seconds), measured flows continuously, and determined daily nutrient loads for a one-year period. In this way, he determined quite accurate total phosphorus and other nutrient loads.

Unger then simulated sampling every third, fifth, tenth, and twentieth day and added another series for each of the three shortest intervals by offsetting the beginning day by one day (e.g., tenth day and tenth day + 1). Deviations from the annual total phosphorus load ranged from -13.8% (tenth day + 1) to +13.9% (third day). The deviation of twentieth-day sampling was -8.2%, and no particular relationship between sampling frequency and deviation from the reference load was evident.

On the basis of these results, Unger concluded that reasonably accurate nutrient loads (margin of error of less than 10%) can be determined by sampling from ten to 20 times per year providing samples are taken at all characteristic stream flows, especially during high flows.

Johnson et al. (1976) studied phosphorus losses from the Fall Creek (NY) watershed during the period of September, 1972, and April, 1974. This study is of particular interest since their Fall Creek sampling site 1 was sampled 13 times by the NES during the period November, 1972, through October, 1973. The stream has a mean flow of about 5 m^3/sec (Anonymous, 1973).

The authors sampled several times a day during most high flows and at three- to 20-day intervals during low flow periods; flows were measured bihourly at a nearby U.S. Geological Survey gaging station. Over 600 samples were collected at their site 1 during the 20-month study period, and analyses of dissolved molybdate reactive phosphorus (DMRP), dissolved unreactive P, solid phase P, and suspended solids were performed. From this rather intensive sampling program, the authors determined that losses of phosphorus from the watershed per unit of time varied considerably, and 75% of the loss occurred during highest flows which occurred 10% of the time. They also concluded that if exports are calculated using total discharge and mean concentrations in samples taken at random or on a fixed schedule, errors would range from slight in the case of dissolved unreactive P (concentrations not flow-related) to severe in the case of solid phase P and suspended solids (concentrations directly related to flows).

Although their study period overlapped the NES sampling period, only six months of their data on parameters common to both studies (DMRP and flows) can be compared. For months with low discharge rates (September and October, 1972, and May through November, 1973), the authors lumped the data and presented only the totals of the loads and flows for those nine months in their report (Table 3, page 152). Also for those months, their DMRP and suspended solids loads were calculated by a method different from that used in the remainder of their study (i.e., the mean of measured concentrations for each of the nine months times the sum of the bihourly discharges for those months).

The DMRP exports of the authors for other than low-flow months were calculated using an equation which included a factor for conversion of instantaneous flux to kg per two hours, the instantaneous bihourly discharge rate, monthly coefficients obtained from regression equations of DMRP on discharge and rate of change of discharge, and the bihourly rate of change of discharge. For the six comparable months, the sum of the authors' DMRP loads differs by 285 kg (7.2%) from the NES load calculated using mean daily flows and concentrations. Considering the different methods of calculation and differences in analytical techniques (e.g., analytical precision, sample preservation, centrifugation vs NES filtration, and stannous chloride vs NES ascorbic acid reduction), the two loads are quite comparable (3,675 kg vs NES 3,960 kg).

The flow data reported by the authors are almost exactly the same as the mean monthly flows the U.S. Geological Survey provided the NES (three of the six are identical, and overall there is a difference of only 1%). This is not unexpected since the gaging station at which both sets of flow data were obtained is equipped with a water-stage recorder that provides a continuous graph of the fluctuations of water surface elevation (Anonymous, 1973).

Welch (1977) conducted an even more intensive sampling program than that used in the Fall Creek study cited above to determine nutrient loads in Issaquah Creek, WA (mean flow of about 4 m^3/sec). By continuous monitoring of the stream during water year 1973 (over 1,000 samples with continuous flow measurement) he found that daily observations were necessary to avoid missing from 25 to 30 percent of the annual total phosphorus export that occurred in four-day periods of peak runoff in each of two consecutive years.

On the basis of the results of the studies cited above, it appears that intensive sampling may not be necessary to determine phosphorus loads in larger streams with acceptable accuracy (ref. Unger, 1970) but that more intensive sampling than was possible during the Survey may be necessary for accurate measurement of phosphorus loads in smaller streams. However, note that while Johnson et al. (1976) found that 75% of the phosphorus export of Fall Creek occurred in 10% of the time, Welch (1977) found that 25 to 30% of the Issaquah Creek export occurred in four days, and Malueg et al. (1975) reported that no relationship could be established between nutrient concentrations and flows in four small tributaries of Shagawa Lake, MN (mean flows of from 0.02 to 0.25 m^3/sec). These differing findings indicate that it would be necessary to make determinations of sampling frequencies needed on a stream-by-stream basis. Given the scope of the Survey, that would have been a virtually impossible undertaking and probably would have exhausted the total resources of the Survey in just one of the larger states such as Minnesota where 89% of the streams sampled had flows of less than 5 m^3/sec.

At this point in time, there may not be any sure way of determining the degree of error, if any, in the nutrient loads measured by the NES. Ideally, one could compare NES loads with those determined by intensive sampling during a comparable period of time, as in the Fall Creek Study, with an assumption of no error in the reference study. However, as far as is known, Fall Creek is the only case in kind, and even there the comparable data are so limited as to make any conclusion somewhat debatable.

Lacking comparable loading studies based on intensive sampling, we reviewed the data obtained in 1972 on 80 lakes and 167 tributaries in the states of Michigan and Minnesota to determine what the consequences of a sizable error in stream nutrient loadings might have been in terms of our assessment of nutrient controllability, the primary end-product of the Survey effort. Assuming the improbable case that all NES phosphorus loads in the 167 tributaries were in error by plus or minus 30% , we found that our assessment would be changed for only 12 of the 80 cases (15%).

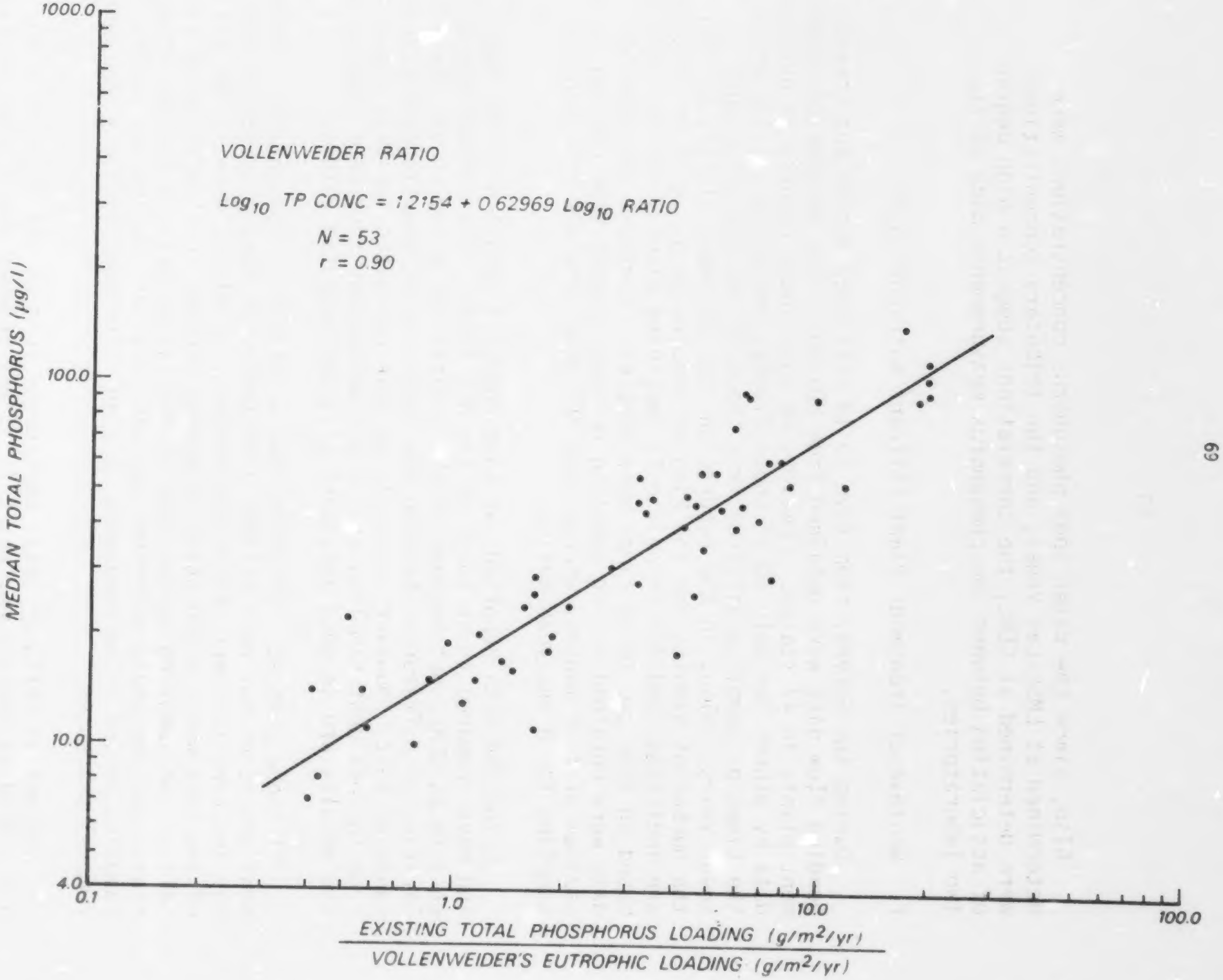
Another way of assessing the validity of the NES stream phosphorus loading data is by using loading models with the NES data to evaluate the relationships between tributary phosphorus loads or concentrations and the in-water-body phosphorus concentrations. For this exercise, we used a data set of 53 NES water bodies in the southeastern states and the input-output model of Vollenweider (1975) and the conceptually-similar models developed by Dillon (1975) and Larsen and Mercier (1976). For brevity, we describe below only the use of the Vollenweider model as an illustration of the application of all three models.

First, we converted the absolute total phosphorus loadings of the 53 water bodies, in grams of total phosphorus per square meter of surface area per year, to ratios by dividing the measured loadings by Vollenweider's eutrophic loadings. We then regressed the logs of the median in-water-body total phosphorus concentrations on the logs of the loading ratios and determined the coefficient of correlation (r). Using the Vollenweider model, r = 0.90 (the regression equation and the line of best fit are shown in the graph on the following page).

Similar regressions were calculated for the other two models. With the Dillon model, r = 0.93, and the regression equation is $\log_{10}$TP concentration = 1.2722 + 0.91086 $\log_{10}$ratio. With the Larsen-Mercier model, r = 0.94, and the regression equation is $\log_{10}$TP concentration = 1.2566 + 0.90778 $\log_{10}$ratio.

Further, in his assessment of phosphorus models for lake management, Reckhow (1977) utilized the NES data on 64 water bodies north of 40° latitude that were sampled in 1972 and 1973. In his critical evaluation of these data, Reckhow stated (chap. 3, pg. 9) "...it is interesting to find that despite the still uncertain impact of hydrologic budget changes on the nutrient concentrations of some lakes, and the possible violation of the steady-state assumption for some lakes, the correlation between the log of the outflow [median] total phosphorus concentration and the log of the lake median total phosphorus concentration is .96..."

These high coefficients of correlation indicate that if the NES phosphorus loadings are significantly in error, the errors are consistent in magnitude and direction, at least for the tributaries and outlets of the 117 water bodies included in the two data sets discussed above. Further, if the loadings are in error, then the in-water-body phosphorus concentrations must also be in error in the same direction and to the same or very similar degree (a possible but unlikely coincidence).


VOLLENWEIDER RATIO
Log10 TP CONC = 1.2154 + 0.62969 Log10 RATIO
N = 53
r = 0.90
MEDIAN TOTAL PHOSPHORUS (µg/l)
1000.0
100.0
10.0
4.0
0.1
1.0
10.0
100.0
EXISTING TOTAL PHOSPHORUS LOADING (g/m2/yr)
VOLLENWEIDER'S EUTROPHIC LOADING (g/m2/yr)

Also, since the water body phosphorus concentrations were determined at EMSL-Las Vegas, and the tributary concentrations were determined at CERL, the correlations suggest a high degree of association between the phosphorus measurements made at the two laboratories.

F. Wastewater Treatment Plant Effluent Nutrient Loads -

During the Survey, from five to 14 effluent samples and corresponding flow data were obtained from 801 municipal wastewater treatment plants in 47 states. However, we have found reports of nutrient data by others for only 16 of those plants, including six for which the times of sampling differed from those of the NES by as much as seven years. Also, in the reports on four of those plants, neither the number of samples nor the kind of samples (e.g., grab or composite) are indicated; and for 11 of the 12 remaining plants, the NES data are based on from two to 14 times more samples. Further, the reported data were obtained during sampling periods ranging from one day to a maximum of four months, whereas the NES data resulted from monthly sampling for a one-year period.

Using the data reported, we have computed annual nutrient loads and have compared those loads to the NES loads. The comparisons are on file at CERL, but because of the limitations noted above, the similarities or differences between the loads are of questionable significance at best. However, recently we have evaluated the data resulting from the effluent sampling at the 801 wastewater treatment plants, and the results are in good agreement with the expected values.

Of those sampled, 702 plants had a variety of conventional treatment processes but were neither affected by phosphate detergent bans nor included tertiary phosphorus removal, 42 plants were in the state of New York where a phosphate detergent ban was in effect during about half of the sampling period, and 25 facilities were in Indiana where a state-wide phosphate detergent ban was in effect during the entire sampling period. The remaining 32 plants included tertiary phosphorus removal processes.

The median effluent total phosphorus load of the 702 plants was 1.0 ± 0.04 kg/capita/year which is midway between the 0.8 kg/capita/year reported by Vollenweider (1968) and the 1.2 kg/capita/year reported by Bartsch (1972). The median effluent total phosphorus load of the Indiana plants was 0.5 ± 0.10 kg/capita/year as would be expected since phosphate detergents account for about half of the phosphorus load in sewage (Anonymous, 1970; Sawyer and McCarty, 1967). The median per capita effluent phosphorus load of the New York plants was midway between the no-ban plants and the total-ban Indiana plants at 0.7 ± 0.10 kg/capita/year.

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APPENDIX

F-1

APPENDIX F

SCIENCE ADVISORY BOARD
ECOLOGY ADVISORY COMMITTEE
ADVISORY STATEMENT

THE NATIONAL LAKE SURVEY PROJECT

The Ecology Advisory Committee of the Science Advisory Board recognizes that the National Lake Survey Project has served an admirable purpose in supplying characterization of some 800 lakes and reservoirs in the contiguous United States. The National Lake Survey Program was conceived originally as the Office of Research and Development's contribution to a policy paper being developed by the U. S. Environmental Protection Agency on possible requirements for municipal wastewater treatment plants to remove phosphate from sewage by processes beyond secondary treatment. The purpose of this requirement would be to prevent the accelerated eutrophication of water bodies related to the nutrient content of effluents discharged from those treatment plants. In order to carry out this program, data were collected from the States on lakes and reservoirs that have various types of eutrophication problems. The relationship between the locations of these lakes and reservoirs and the location of the discharge from the sewage treatment plants, either directly into the lakes and reservoirs or into feeder tributaries into the lakes and reservoirs, was a major factor in the selections for survey.

A crash program of sampling of water chemistry and plankton productivity in as many lakes and reservoirs as possible was undertaken in order to identify those that are limited in productivity by nutrients or abiotic factors. In addition, of those lakes associated with a sewage treatment plant as a sole point-source nutrient input, the degree of tertiary treatment (selective nutrient removal) necessary to "stabilize" the productivity of a water body and possibly lead to a reversal of the process symptomatic of cultural eutrophication might then be projected.

At approximately the same time, the Agency was required to respond to the Congress on certain initiatives in the restoration of eutrophied lakes and impoundments under other legislative mandates. Information gathered for the National Lake Survey program paralleled information needed for Congresionally mandated reports. The Lake Survey Program, therefore, acquired an additional purpose.

Initiated in 1972, this Survey of more than 800 bodies of water in the contiguous United States will be concluded in late 1975 upon the completion of the sampling of the western sector of lakes and reservoirs. Data analyses will require one more year. It is recognized that because the Survey is a crash program, conducted over a relatively short period of time and with a limited sampling program, the data obtained will be relatively crude.

October 23, 1975

The Committee states further that because of the non-random selection of the lakes and reservoirs and the limited sampling program of limnological parameters, the results of the Survey must be viewed with some caution. The Committee has severe reservations about the suitability of the National Lake Survey data for extrapolation and generalization. There is a concern that premature evaluation of these data may lead to incorrect conclusions and result in bad management practices.

In order to strengthen the credibility of the study, the Committee recommends that:

- The National Lake Survey data should be compared with existing data on the many well-studied lakes of similar type.
- The comparisons of the results should be discussed in personal conference with limnologists who have collected and assessed data on the same or similar lakes and impoundments covered by the National Lake Survey.
- The National Lake Survey estimation techniques should be applied to data already available on additional well-studied lakes and impoundments and those results should be compared. This will enable one to test the degree of error one may expect to find and thus provide an evaluation of the reliability of the Survey itself.
- Only after such comparison should further efforts at extrapolation and generalization through the computer be carried out.